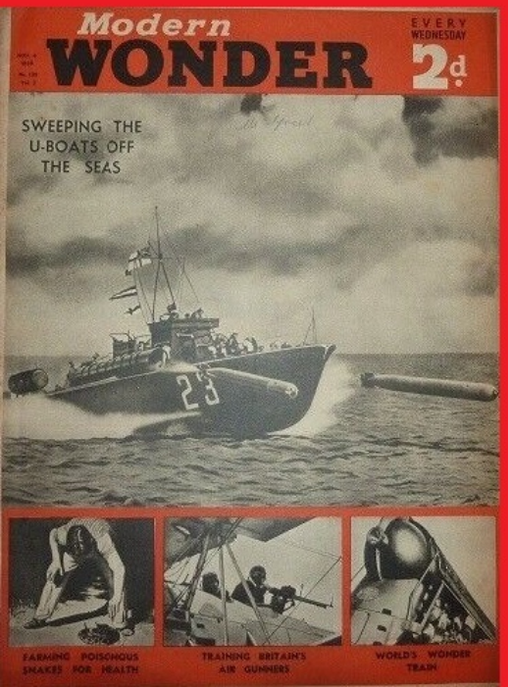
MODERN WONDER

1937-1940

VOLUME 2



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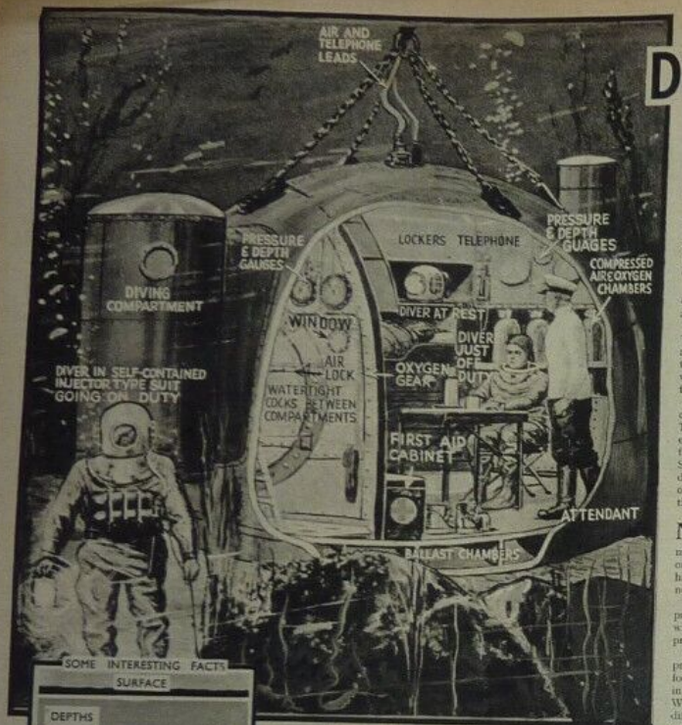
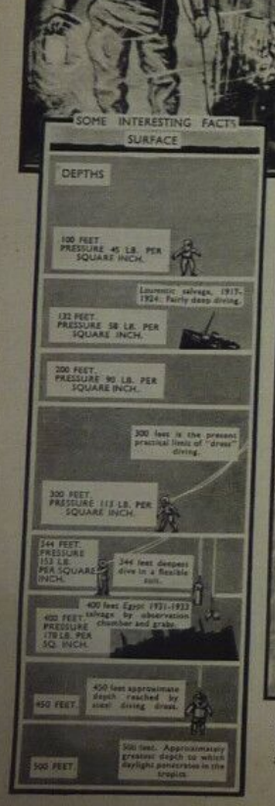
DEATH LURKS

By PROFESSOR





(Top) **Cut-away sketch shows the latest type of deep-sea diving chamber, which obviates necessity for returning to surface each time.** *(Left)* **This chart gives some interesting facts in connexion with modern diving methods.** *(Above)* **A pupil of the Naval Diving School is just about to make his first venture below the surface.**

Pushing himself against a strong current is one of the diver's most laborious jobs. Very little useful work can be done in a current exceeding 2½ knots, as the constant struggle hampers movement.

I WONDER whether you think of a physiologist like me as sitting at a laboratory bench doing experiments with very complicated apparatus on a frog's heart or a sprouting barley corn. Of course we do that kind of thing, but we also do quite simple experiments on ourselves and other people, in conditions much more exciting than those of the laboratory.

Now I am going to tell you how physiology has been applied to save the lives of men who have to work in air at abnormal pressures.

First of all I will talk about work in compressed air. There is only one reason why men have to work in it, and that is to keep out water. The men who tunnel through the London clay to make our underground railways have to work in compressed air to keep the water from flooding the tunnel.

The air which is pumped down to a diver has to be compressed in order to get it down the pipe to him. The greater the depth the greater the pressure. For every thirty feet of salt water or thirty-three feet of fresh water an extra atmosphere's pressure is needed. So a diver at 330 feet below the sea, which is the greatest depth reached in an ordinary dress, is under a pressure of twelve atmospheres, one due to the air and eleven to the water.

Now let us see what his dangers are. One of the simplest is that the pump which compresses the air sent down may leak at high pressures, so that he is suffocated, or at best very short of breath. But let us suppose he has a good pump and plenty of power to work it, what next?

Thirty years ago people thought that the extra pressure was dangerous in itself, and divers were provided with wicker-work baskets like crinolines to keep the water pressure off their bodies.

Of course it sounds very alarming to hear of an extra pressure of 150 lb. per square inch, or ten tons per square foot, but we have to support one-tenth of that pressure in ordinary life, and don't notice it. Nor does the diver. What damages the human body is not pressure, but differences of pressure. For example, if the diver had only one atmosphere's pressure inside his lungs and ten outside, his chest would cave in.

The only place where difference of pressure is likely to hurt a diver is in the ears. On one side of the ear drum there is a tube communicating with the outside, on the other a tube called the Eustachian tube, leading into the throat. If the pressure on the two sides is unequal you get first discomfort, then pain.

The underground railway worker can equalize the pressure on the two sides of his drums by shutting his mouth, holding his nose, and blowing. If you do that you will feel your Eustachian tubes blown out, and hear a clicking noise in your ears like the noise when you swallow.

The diver has a glass window between his nose and his fingers, so he has to open his Eustachian tubes by swallowing. If the diver has a bad cold his Eustachian tubes may get blocked, and if in spite of this he goes down, he may burst one or both ear-drums, which is very painful, and makes him deaf till they are mended.

It is quite easy to learn in a compressed air chamber how to open your Eustachian tubes, and once this is learnt you can go down as fast as you like. At one time divers were supposed to go down very slowly. This was quite unnecessary.

My first experience of diving was when I was thirteen years old. My father was investigating the physiology of diving for the Admiralty, and in order to demonstrate the safety of rapid descent by untrained people, he offered me up, like Isaac, or more accurately down. I stayed down for about half an hour at forty feet after one lesson in Eustachian tube opening in a compressed air chamber. This was a little more exciting than it sounds, because the diver's hand are free and the water is kept out of his dress by rubber cuffs.

As my wrists were too small for the cuffs, the water came in, and by the time I came up, it was up to my neck. Of course the air which was pumped down to me prevented it rising any higher, but I was very cold indeed.

The diver is generally safe enough on the bottom, but when he comes up care is needed. His danger is from bubbles which may form in his blood or tissues when the pressure is taken off, just as they form in a bottle of lemonade or soda water. There is a story that when one of the first tubes was being driven under the Thames, the directors of the company celebrated its arrival under the middle of the river by having lunch in the tunnel.

They went into an air lock, the steel door was shut behind them, and the pressure raised till it reached that in the end section of the tunnel. Then a door at the other end was opened, and they went on to lunch. As you know, company directors always have champagne for lunch, and these were no exception to the rule. But when the bottles were opened the champagne did not fizz. The pressure outside the bottles was as great as that inside them. However, the directors drank the wine. After lunch they went back to the lock, and the pressure was lowered. They soon began to feel very uncomfortable. As the pressure fell the wine began to fizz, and the financiers to suffer from inflation!

The bubbles in divers are not of carbon dioxide, as in champagne, but of nitrogen. All the time that they are breathing compressed air, their blood takes up more nitrogen and oxygen than usual. The oxygen is used up, but the nitrogen goes into the tissues, especially into fat, and tissues like nerve and brain, which contain a great deal of oil in which nitrogen dissolves easily.

If the pressure is taken off too quickly, bubbles may be formed. If they form in nerves the strain on the fibres causes pain, paralysis, or both. If in the blood, the vessels of the lung or heart may be blocked, and the diver loses consciousness and may die in a few minutes.

There are two ways of dealing with this trouble: prevention and cure. The diver must stay as short a time as possible at the bottom if he is going deep. For example, only twelve minutes are allowed at two hundred feet. He then comes up about half-way to the surface.

If he came too far he would be in danger of bubbles; if he did not come far enough he would still be absorbing more nitrogen than desirable. He stays at this pressure for a certain time and then comes up by stages which have been calculated, and the calculations checked by experiments first on goats, and then on men, particularly on Commander Damant and Lieut. Catto, R.N.

But a diver may get entangled at the bottom and stay too long, or a mistake may be made in timing, so that symptoms develop. If so he must be recompressed, so as to make the bubbles get smaller, and finally dissolve again. A diver who had come up too quickly went black in the face and lost consciousness on reaching the surface. His helmet was screwed on and he was dropped overboard. The bubbles in his blood soon dissolved again, and he was able to answer the telephone and to come up safely after waiting for the proper time.

However, it is much better to have a steel chamber at the surface in which men may be recompressed if they develop any symptoms.

To get up the German battle fleet, which was sunk in Scapa Flow, it was necessary first to send down divers to fix tubes to the bottoms of the ships, which had all turned over, and then to pump air down these tubes into the hulls. Other workers went down the tubes into the insides of the ships to close doors between different compartments so that the air could be pumped into the various parts of the ships in the right amounts.

There is one other danger to which divers are exposed, namely, oxygen poisoning. For oxygen, like other good things, is a poison if you have too much of it. A man breathing pure oxygen at ordinary pressure, or air at five atmospheres, which comes to the same thing, will get pneumonia after a day or so. Pure oxygen at three or four atmospheres causes convulsions, and at lower pressures probably affects the brain a little after some time.

So a diver who has been down too long has to choose between the danger of bubbles if he ascends too quickly and oxygen poisoning if he ascends too slowly. Perhaps in future it may be desirable to dilute the air with nitrogen at very high pressures.

In theory all these dangers can be overcome by sending the diver down in an armoured dress which will withstand the water pressure, even though the air inside it is not compressed.

Unfortunately such dresses are so clumsy that the diver cannot work so quickly or accurately as in a flexible dress.

[Reproduced from the Book of Science, "Keeping Cool," by Professor J. B. S. Haldane.

UNDER THE SEA

J. B. S. HALDANE

(Top) **Men at the Naval Diving School learn to dress each other as one of the early lessons before actual diving is started.** *(Above)* **The cut-away sketch of a modern submersible decompression chamber, shows how this modern innovation is utilized to avoid long waits as the diver ascends to the surface from great depths.**

Very rigid training methods are employed to prepare pupils for their subsequent work in the Royal Navy. When qualified they may have to do very tricky work calling for expert knowledge and cool heads.

As new apparatus is developed, men at the Naval Diving School try it out. Besides training pupils to dive, the navy carries out all kinds of experiments so that the latest equipment is always available.

By regulating his air supply, the skilled diver is able to make himself heavier or lighter. This enables him to glide over sea-bed obstacles with giant strides, and is a trick which divers quickly learn.

EMPIRE STANDS TO ARMS

IN recent months reports of colonial troop movements and arrivals have been frequently found in the forefront of our daily news. A seemingly endless stream of men has been pouring into these islands from Canada, Australia and New Zealand. Indians have arrived and are established in France. The Annacs have taken up their valuable strategic position in Egypt strengthening our already established garrisons in the near East. The Australians have landed in Palestine where they are continuing their training and increasing their efficiency. Contingents of men have been sent to the B.E.F. from even such small domains as Cyprus and Newfoundland.

All these facts point to one all important aspect of this war, which Hitler is doing his best to forget—that the British Empire is throwing the whole of its weight and man power into the conflict that the Nazis chose to inflict on the world. If Germany was hoping that the Empire would stand by and see the Motherland fight this war alone, she must be sadly disappointed.

Already to the tune of "Roll out the Barrel," troops from Canada and a large squadron of the Australian Air Force, have been landed safely at ports round the coast of Britain and are now firmly established in training quarters in various parts of the country. These men have come of their own free will—they wanted to come, and there are many more like them back in their home colonies.

Enlistment in the various dominions is continuing at high pressure and many have, and are still receiving, more men than they can handle. One thousand men a week, for instance, are being enlisted for service with the Australian Air Force.

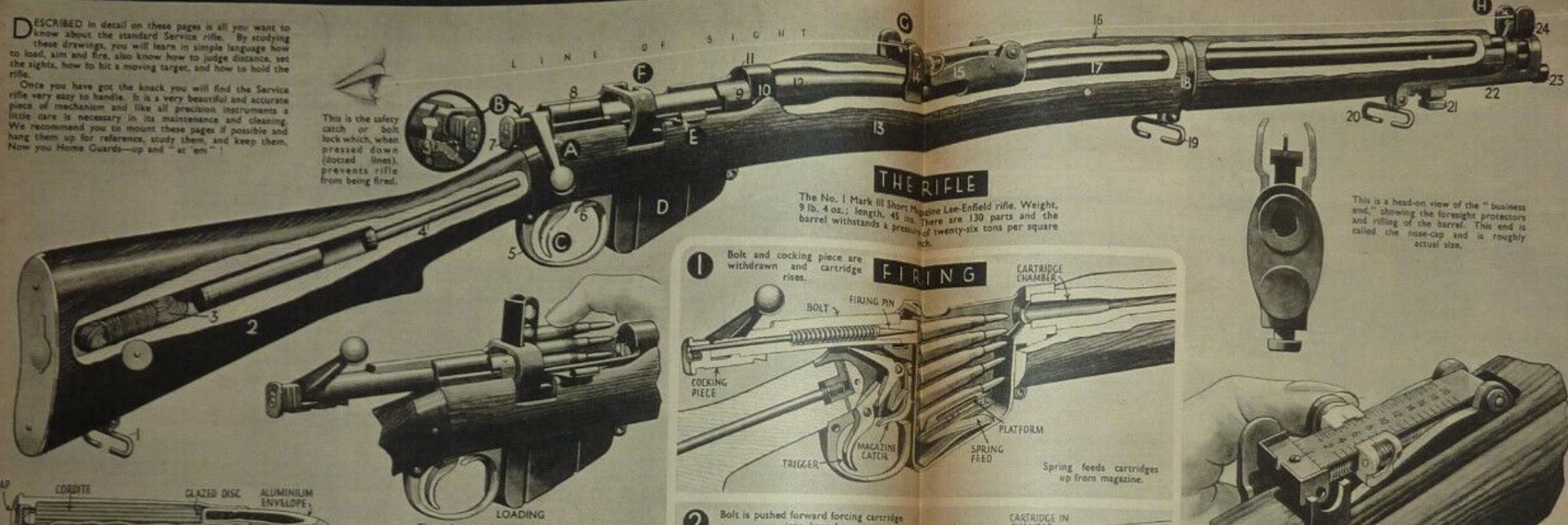
A large contingent of native Indian troops have taken up their positions in France shoulder to shoulder with the B.E.F., and alongside their French comrades. They have come fully equipped and already trained—and they are some of the finest fighters that any country in the world can produce.

The Annacs of glorious memory in the last war for their daring assault on Gallipoli are another factor to be contended with seriously before Germany can contemplate any successful attack on the precious Suez Canal. These men from Australasia are some of the toughest, strongest, bravest fighters at the disposal of any general. Their pleasant weather-beaten faces and cheerful disposition turns to symbols of grim determination when it comes to a scrap.

GET YOUR PARACHUTIST!

DESCRIBED in detail on these pages is all you want to know about the standard Service rifle. By studying these drawings, you will learn in simple language how to load, aim and fire, also know how to judge distance, set the sights, how to hit a moving target, and how to hold the rifle.

Once you have got the knack you will find the Service rifle very easy to handle. It is a very beautiful and accurate piece of mechanism and like all precision instruments a little care is necessary in its maintenance and cleaning. We recommend you to mount these pages if possible and hang them up for reference, study them, and keep them. Now you Home Guards—up and "at 'em"!



THE RIFLE

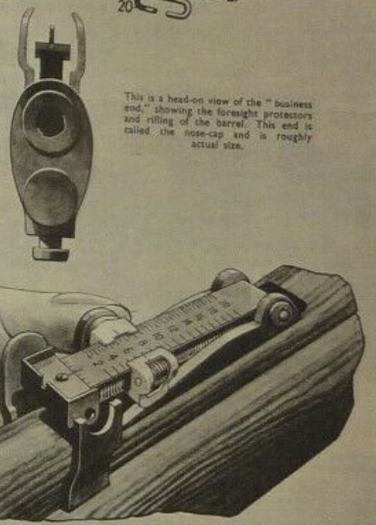
The No. 1 Mark III Short Magazine Lee-Enfield rifle. Weight, 9 lb. 4 oz.; length, 45 ins. There are 130 parts and the barrel withstands a pressure of twenty-six tons per square inch.

THE BULLET

The .303-in. small arms ammunition, Mark VII. Roughly actual size. The bullet has a muzzle velocity of 2,440 feet per second.

LOADING

The safety catch is pushed forward and cut out pulled out and bolt drawn back. The clip of cartridges is placed in the charger guide and cartridges pressed down into the magazine with the right thumb. Close the bolt which will automatically push the top cartridge into the breech. The rifle is now ready to fire.



This is a head-on view of the "business end," showing the foresight protectors and rifling of the barrel. This end is called the nose-cap and is roughly actual size.

KEY TO PARTS

The eight principal parts you are required to use are lettered A to H and they are:

(A) Bolt handle. This is lifted upwards and used for drawing the bolt back. This bolt contains the spring for firing the cartridge.
(B) Safety catch. This locks bolt and prevents firing when in lowered position. To load and fire must be pressed forward and upward.
(C) Trigger. This fires the rifle and is squeezed steadily, not pulled.
(D) Magazine. Holds ten cartridges but five are generally used. Is withdrawn by lifting catch near trigger.
(E) Cut-off. This closes top of magazine, preventing ammunition from rising. Is pulled outwards and downwards to open.
(F) Charger guide. Clip of cartridges is placed in here when loading magazine.
(G) Backsight. This gives elevation to the barrel and is lined up with foresight.
(H) Foresight. This is a blade on the nose-cap which gives direction.

OTHER PARTS

1, Butt sling swivel; 2, butt; 3, cleaning materials in butt; 4, butt bolt; 5, trigger guard; 6, magazine catch; 7, cocking piece; 8, bolt-resisting shoulder; 9, bolt-resisting lug; 10, cartridge extractor recess; 11, breech; 12, cartridge chamber; 13, stock fore-end; 14, backsight protectors; 15, backsight bed; 16, handguard 17, barrel; 18, lower band; 19, lower band sling swivel; 20, piling swivel; 21, bayonet bar; 22, nose-cap; 23, boss for ring of bayonet; 24, foresight protectors.

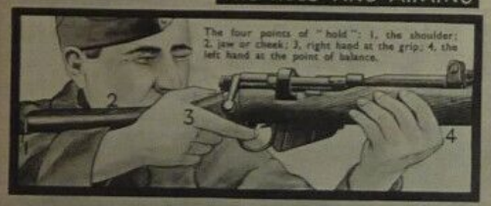
SETTING THE SIGHTS (LEFT)

On the backsight is a slider and this is usually locked at the back end of the leaf. In this position the rifle is correctly sighted up to 100 yards; for longer ranges up to 2,000 yards you hold the rifle with the left hand and press in the locking spring with your thumb. Then push the slider forward until it registers with the range required which is engraved on the leaf for every 100 yards. When you remove your thumb the slider is locked. The screwed wheel on the near side is for very fine adjustment. By pushing the slider forward you raise the backsight, and so give the rifle greater elevation for longer ranges.

PASS THIS CHART TO YOUR LOCAL HOME GUARD

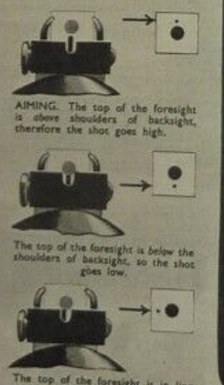
FIRING

THE HOLD AND AIMING



THE "MILITARY" HOLD

The rifle should be held firmly in the left hand at the point of balance; when on aim the wrist should be turned so that the forearm and elbow are directly in line underneath the rifle. The right hand should hold the rifle at the grip, the right elbow should be in line and level with right shoulder. In standing position the body is turned half right; left foot pointing to the front.

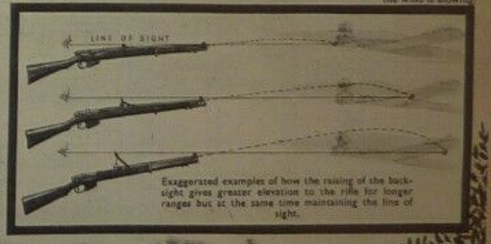


CORRECT AIM

The top of the foresight is at the centre of the bottom of the target; it is in line with the shoulders of the backsight and in the centre of the U.

JUDGING DISTANCE AND AIMING OFF

Using the rifle to help you judge distance. For general purposes it should be noted that at 250 yards and 400 yards, the blade of the foresight of the Lee-Enfield rifle covers a man kneeling and standing respectively.



Exaggerated examples of how the raising of the backsight gives greater elevation to the rifle for longer ranges but at the same time maintaining the line of sight.

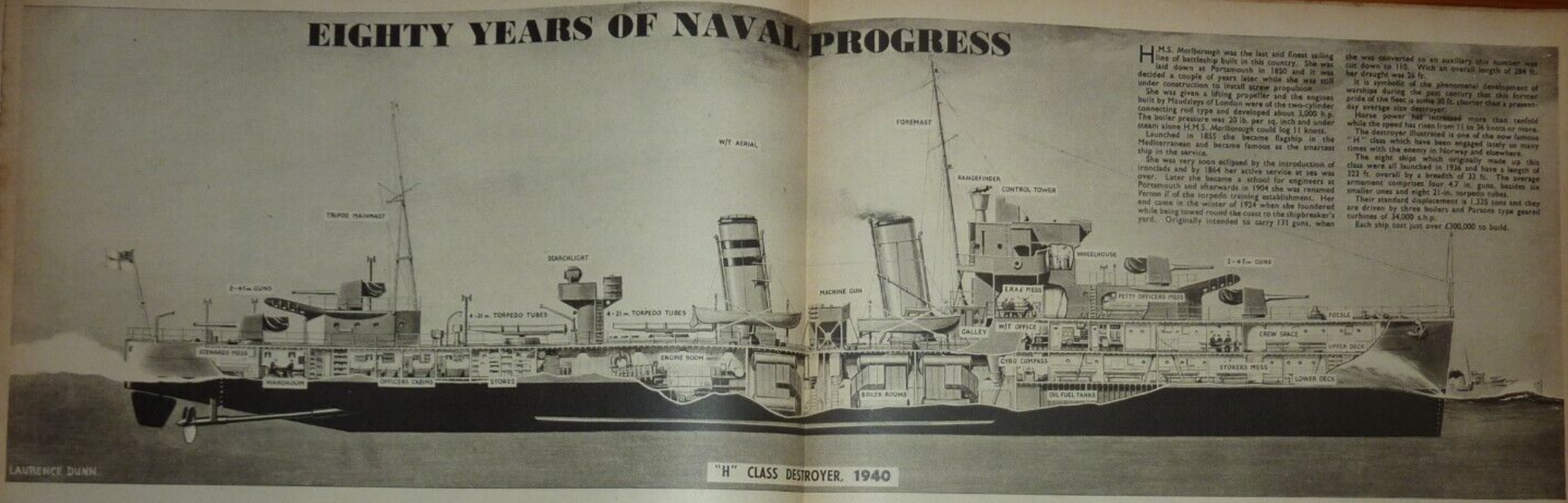
RECOGNITION

The vertical clock method for giving direction from a reference point. Example of fire order: Church tower: right; 5 o'clock; small bush.

DEFINITIONS

Terms used in conjunction with rifle shooting:
LS.—Line of sight.
BE.—Line of departure.
C.—Culminating point.
DH.—Dangerous space.
BCD.—Trajectory.

EIGHTY YEARS OF NAVAL PROGRESS



LAURENCE DUNN

"H" CLASS DESTROYER, 1940

H.M.S. Marlborough was the last and finest sailing line of battleship built in this country. She was laid down at Portsmouth in 1850 and it was decided a couple of years later while she was still under construction to install screw propulsion.

She was given a lifting propeller and the engines built by Maudslays of London were of the two-cylinder connecting rod type and developed about 3,000 h.p. The boiler pressure was 20 lb. per sq. inch and under steam alone H.M.S. Marlborough could log 11 knots.

Launched in 1855 she became flagship in the Mediterranean and became famous as the smartest ship in the service.

She was very soon eclipsed by the introduction of ironclads and by 1864 her active service at sea was over. Later she became a school for engineers at Portsmouth and afterwards in 1904 she was renamed Vernon II of the torpedo training establishment. Her end came in the winter of 1924 when she foundered while being towed round the coast to the shipbreaker's yard. Originally intended to carry 131 guns, when she was converted to an auxiliary this number was cut down to 110. With an overall length of 284 ft. her draught was 26 ft.

It is symbolic of the phenomenal development of warships during the past century that this former pride of the fleet is some 30 ft. shorter than a present-day average size destroyer.

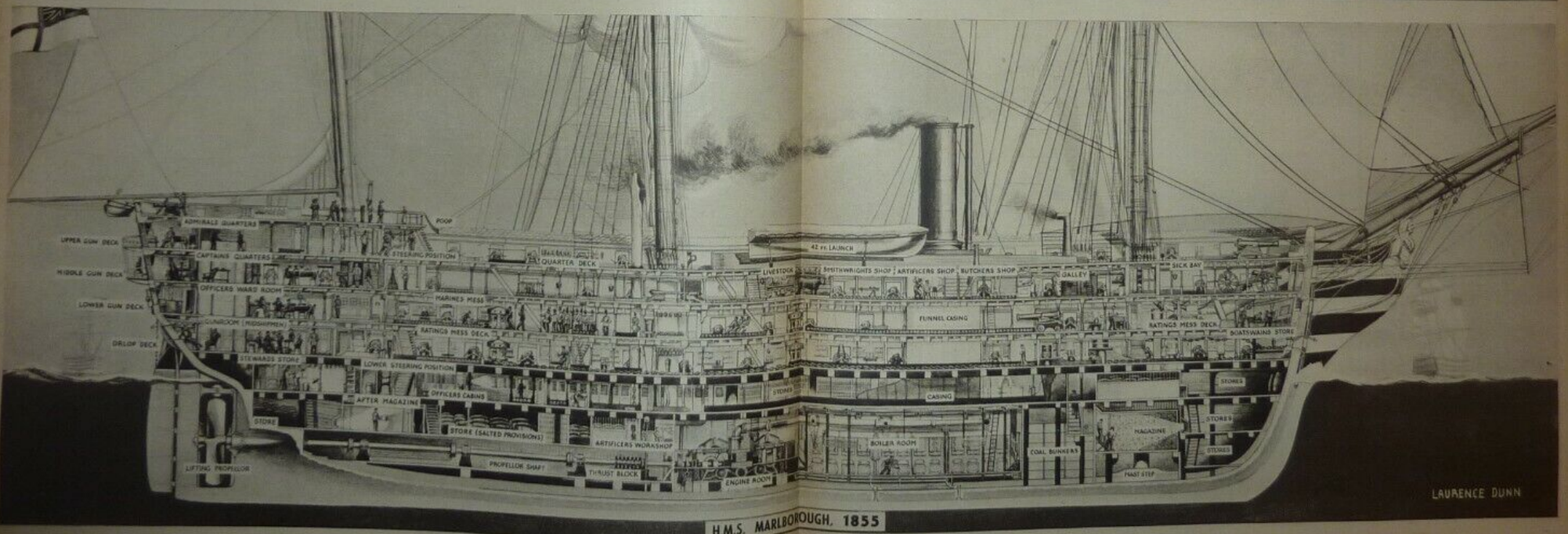
Horse power has increased more than tenfold while the speed has risen from 11 to 36 knots or more.

The destroyer illustrated is one of the now famous "H" class which have been engaged lately so many times with the enemy in Norway and elsewhere.

The eight ships which originally made up this class were all launched in 1936 and have a length of 323 ft. overall by a breadth of 33 ft. The average armament comprises four 4.7 in. guns, besides six smaller ones and eight 21-in. torpedo tubes.

Their standard displacement is 1,335 tons and they are driven by three boilers and Parsons type geared turbines of 34,000 s.h.p.

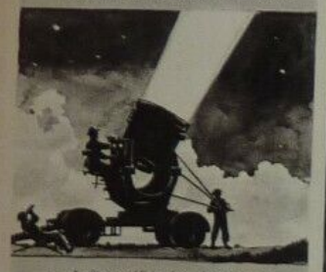
Each ship cost just over £300,000 to build.



LAURENCE DUNN

H.M.S. MARLBOROUGH, 1855

The sound locators or "ears" of the "sky guns" pick up the purr of the raiding planes. . . .

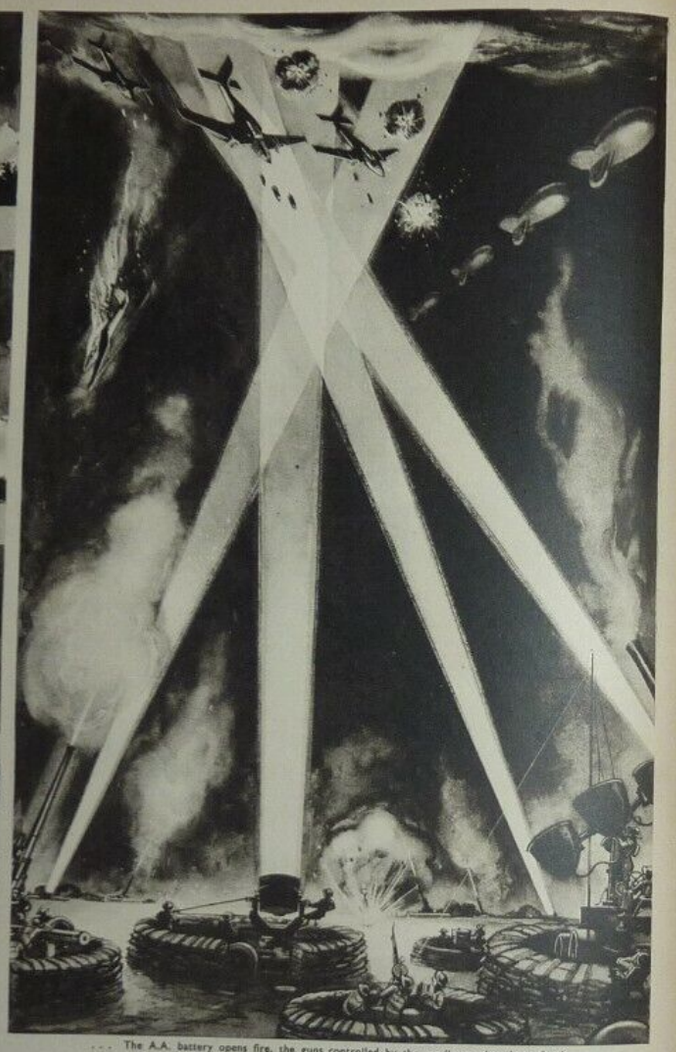


. . . A pilot searchlight glares skywards in the direction indicated by the sound locators. . . .

. . . All around the horizon great shafts of light hunt around the pilot beam seeking the enemy plane. . . .

The plane illuminated, the height-finder operators train upon it, take the altitude of the moving target. . . .

. . . This is transmitted electrically to the "brains" of the "sky guns," the almost human predictor. . . .



. . . The A.A. battery opens fire, the guns controlled by the predictor, the planes fixed in the glare of the searchlights.

NOW THE SKY GUNS SPEAK

ANTI-AIRCRAFT guns guard the skies of Britain these days as the net of aerial bombardment spreads ever wider. The "sky guns" girdle the cities, protect ammunition dumps, air fields, G.H.Q.'s, navy yards, armies, against the terror from the skies. Anti-aircraft guns and their expensive equipment are an increasingly important item in the armoury of Mars.

A typical anti-aircraft battery, such as the one shown in action on this page, consists of these units: a number of *anti-aircraft guns*, possibly of the 3.7 in. type and regarded as the finest in the world; a battery of *sound locators* or "*ears*," which are used at night to pick up the sound of aeroplane engines; *searchlights*, some of them throwing beams of 800,000,000 candlepower; and a *height finder*, which computes the altitude of the planes once the searchlights have focused on them, and transmits it to the *predictor*, a complicated, electrical calculating machine that computes semi-automatically firing data which is then electrically transmitted to each of the guns.

Anti-aircraft gunfire presents one of the most intricate ballistic problems, and the equipment—searchlights, locators, fire control instruments—which makes possible the successful firing of the guns is correspondingly intricate.

In the World War, in Britain alone, there were almost 500 anti-aircraft guns, 700 searchlights, 245 height finders and thousands of men. In this war, with the menace of the plane much more acute, the answer of the "sky gunners" is many times more emphatic, and a considerable part of the country's strength is earmarked for these purposes alone.

THE MOON WILL EXPLODE!

ALAS for the moon, lovely ornament of the night sky. A dire fate awaits her. In the remote future she will be broken up into myriads of tiny fragments forming a great ring round our earth.

Such destruction she brings upon herself by her own action. She has a peculiar attraction for the waters of the ocean on the earth's surface, and the effect of this attraction is such that it creates two simultaneous high tides, a major high tide on the side of the earth nearest the moon and a lesser high tide on the opposite side.

As the earth is rotating once every twenty-four hours and the moon is revolving round it in about twenty-seven days, the tidal protuberances are carried a little forward; they are a little off the line joining the centres of the earth and the moon. These tidal projections are pulled at by the moon, and the earth has to rotate on its axis against the pull. Hence it tends to be constantly though very slightly dragged back.

The tides thus act as a brake on the earth's rotation. Consequently, the rotation of the earth is getting slower and slower, which means that the days are getting gradually longer. Today is longer than yesterday, tomorrow will become longer than today. Every day is slightly longer than the one before, the difference being so very small that not until 100,000 A.D. will the day be one second longer. But such a minute difference is bound to make itself felt through the millions of years during which the earth may exist.

Southern portion of the moon as seen from the Wilson Observatory.

This is not the only effect of the tides raised by the moon on the earth. All action has an equal and opposite reaction. As the attraction of the moon tends to turn the earth backwards, the attraction of the projections on the moon tends to pull the moon forwards. The effect will be to drive the moon farther off.

The moon will, therefore, have to describe a larger orbit. But the larger the orbit, the longer the time the moon will be in traversing that orbit. Hence the tidal reaction on the moon has the effect of not only driving the moon farther off but also of lengthening the month.

Let us take a glance back into the profound depths of times past. If the present order of things has lasted, the day must have been shorter and, shorter the farther back we look into the dim past, the moon nearer and the month shorter.

The shorter the day, the faster should the earth be spinning; the faster the earth is spinning, the more is the earth bulged at the equator. The more the earth is bulged at the equator, the greater the strain put upon the materials of the earth by the centrifugal force of its rotations.

When the earth is rotating, the materials composing the earth, and everything on its surface, you and I, are held together by gravitation. The gravitational force is greater, considerably greater than the centrifugal force, so that you and I don't fly off the surface of the earth.

If the earth spins very fast, the centrifugal force would get the upper hand; the force of gravitation would be wiped out, and you and I and the materials composing the earth would have to fly off. And when it is reckoned how fast the earth must spin for gravitation at its surface to be annulled and for portions to fly off, we get one revolution every five hours.

Calculation reveals that the earth should have attained this critical speed some four thousand million years ago. The day then could never have been shorter than five hours; for, if it were, the earth would have a tendency to fly to pieces, or at least, to separate into two bits.

What had been happening to the moon during all these four thousand million years? As a result of tidal reaction the moon is receding from us and the month is becoming longer. Rotating the cinematograph film backwards, we see the moon coming closer and closer to the earth and revolving round it quicker and quicker, and ultimately touching the earth.

And when it is worked out how long the moon should take to revolve when it is in close contact with the earth, we get a period of five hours just four thousand million years ago, when the earth too was rotating in the same period.

The moon, therefore, should originally have been a part of the earth and should have separated from it when the earth was rotating at greater than the critical speed.

So, then, four thousand million years ago there was no moon; only the earth as a molten globe was rapidly spinning on its axis, spinning in just under five hours. Immediately the great globe separated into two, one about eighty times as big as the other. The biggest one we call the earth and the smaller one we now call the moon.

Round and round the two bodies went, raising tides on each other, and each putting a brake on the other's rotation, and as a consequence receding from each other. Because the moon is the smaller body, its rotation was much sooner wiped out, so that it now presents the same face to the earth. This process of raising tides has now lengthened the day to twenty-four hours and pushed the moon to its present distance of 240,000 miles.

Still the stately march of events goes on; the day getting longer and longer, the moon more and more distant, and the month longer and longer. A stage will come when the period of rotation of the earth would be again equal to the period of revolution of the moon. Calculation shows that this happens in about fifty thousand million years from now.

Dr. Jeffreys, who made the calculation, says that at this remote time the earth's rotation and the moon's revolution would both take place in about forty-six of our present days.

When the day and the month become equal, the earth and the moon will remain permanently, each keeping the same face towards the other.

But this state will not be final. We have forgotten the sun's tidal action. The sun, too, like the moon, produces tides but of lesser magnitude because of its greater distance. They will continue to retard the earth's rotation, so that the day will be lengthened without the month being affected.

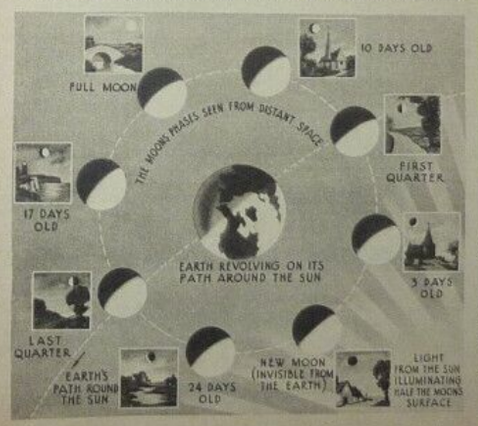
The moon will, therefore, be travelling at a faster angular speed than the earth rotates, so that it would appear to move eastward in the sky. An observer on the earth will then see the moon rise in the west and set in the east.

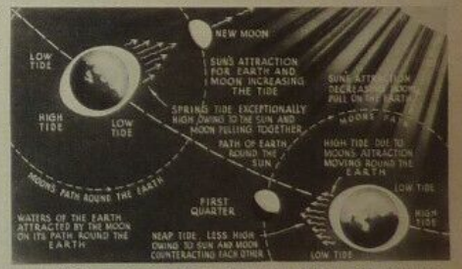
As a matter of fact, in the Martian sky one of the moons, namely Phobos, rises in the west and sets in the east, and it does this three times every day, because the period of revolution of Phobos is seven hours thirty-nine minutes, while the period of rotation of Mars is twenty-four hours thirty-seven minutes.

When the day becomes longer than the month, the lunar tides will again be at work, but their effects will now be reversed. As the earth now rotates in a longer time than the moon revolves in, the tidal projections will be a little behind the line of centres of the earth and the moon.

The effect will, therefore, be to accelerate the earth's rotation, instead of retarding it, and to bring the moon nearer instead of pushing it farther off.

The complete capture of the moon will take some billions of years; but it is bound to come. When it comes within the danger zone, which is about 10,000 miles from the earth, the tremendous disruptive forces will cause the moon to break into myriads of bodies of various sizes.

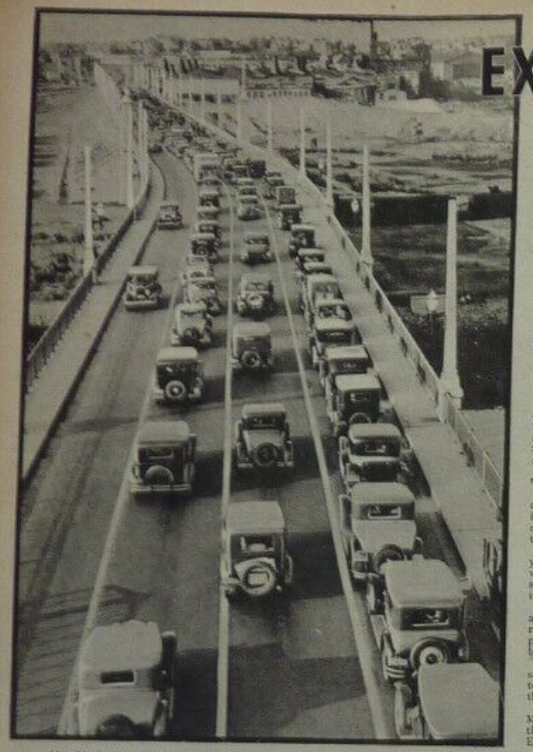




(*Above*) **Diagram shows how the gravitational effects of the sun and moon cause tides.** (*Left*) **Moon phases caused by the moon moving in its orbit round the earth.**

EXPRESS HIGHWAY

BUILT ON AN ABANDONED RAILWAY A NEW AMERICAN ROAD WILL GIVE SAFE TRAVEL AT 120 m.p.h.



New York has gone far towards solving traffic problems on Victory Bridge. Note the orderly lines of cars.

EVERY year sees an accentuation of the vast gulf between the American and the British conceptions of the future of road transport. Nothing emphasizes this more than the project described in this article.

The first stretch of 160 miles of an American express highway is nearing completion. It will be a toll road, safe for 120 m.p.h.—an exclusive motor speedway.

The origin of this highway is a romance in itself, for it was begun over a hundred years ago as a railway.

To begin this story of fruitless labour, of millions of dollars thrown away, we go back to 1837. From the earliest days of American history the Appalachian range of mountains formed a 1,500-mile barrier in the journey between the Atlantic and the Pacific coasts of the "New World," and adventurous explorers sought a way westward.

Further difficulties were provided by the Alleghenies, with their narrow mountain roads and tracks, in Pennsylvania.

The 1830's saw the beginning of the railway era and the State of Pennsylvania in 1837 conceived the idea of a railway route from Chambersburg, in the Cumberland Valley, to Pittsburgh, 125 miles to the west.

They sent out their surveyors, one of whom was an apprentice engineer, John A. Roebling, who in later years built the suspension bridge across the Niagara Falls, and the Brooklyn Bridge at New York. Some $300,000 were spent in a voluminous survey, which reposed for forty years in the archives of the State.

So things remained until 1881, when there was a fierce war between various railroad interests, represented by William H. Vanderbilt, of the New York Central Railroad, and J. Pierpoint Morgan, of the Pennsylvanian Railroad.

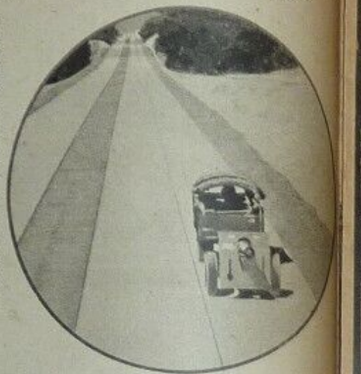
In an attempt to kill the Central's monopoly of rail traffic through the Hudson Valley, Pierpoint Morgan purchased the Western Shore Line. Vanderbilt retaliated by building a railway between Harrisburg and Pittsburgh in the heart of the Pennsylvanian Railroad's domain, a double track of 164 miles. It became known as "Vanderbilt's Folly."

And that was the beginning of the express highway, now built over the original railroad.

The railway track cost $10,000,000—over a couple of million pounds in our money. These giants of transportation, however, never worried about cost, particularly as their financial schemes found ready backing by the public.

Andrew Carnegie, the Pittsburgh steel king, was in with Vanderbilt. He had fought the Pennsylvanian Railroad for years over the rates for transporting steel to the Atlantic seaboard, and when Vanderbilt sounded him on the proposal to construct a rival line, felt for it right away.

Asked what he thought of the idea, he said: "I think so much of it that I and my friends will raise $5,000,000 as our subscription."



A stretch of the new American 160-mile highway built on the foundations of an abandoned railway.

Then the new line was floated on the financial market and $40,000 in stocks and bonds eagerly absorbed by a trusting public.

The work commenced at once. For two years 3,000 engineers explored the mountain wilderness and made what is still considered the most complete railroad survey in the United States.

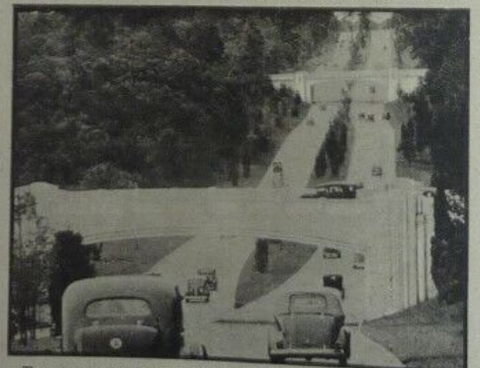
The surveyors having done their work, an army of labourers began blasting the rocks with dynamite, felling forests, piercing the mountains with tunnels and bridging rivers and streams.

In November, 1885, the railway was sixty per cent completed, including tunnels to the length of four and a half miles driven through the solid rock.

What happened? Vanderbilt and Morgan shook hands. The war was over, the railway was no longer needed. Engineers, officials, workers were sacked without notice. The line, which had cost twenty-seven lives and $10,000,000, was abandoned.

In 1890 "Vanderbilt's Folly" was sold by the sheriff. In the annual report of the Inter-State Commerce Commission it figured in the books at a valuation of one dollar.

From 1885 to 1934 the railway was almost forgotten. Water filled the tunnels and the track was lost in undergrowth. Then the Pennsylvania State conceived using the old railway as the basis of a modern motor road.



The new motor road has numerous ingenious methods for overcoming traffic dangers. Bridges are provided to avoid intersections, thus maintaining speed.

The planning board, poring over the dusty files of the survey, decided that completion of seven of the nine tunnels would provide a highway with easy grades, ideal for heavy trucks, a road protected against mountain storms and fogs, which would save several hours' running time between Philadelphia and Pittsburgh. A further survey was made in 1936.

The tunnels were drained and the road bed cleared. The engineers found that Vanderbilt's workmen had done a good job. The masonry was sound and the arches well preserved. The work that had been valued at one dollar was now estimated to be worth several million dollars.

In the intervening time, nearly fifty years, America had grown up, with big towns and cities, farms, factories and roads. Projectors of the roadway, however, conceived a turnpike available for the fastest motor traffic that could use it, from which seventy-five per cent of the causes of accident would be eliminated.

In May, 1937, just a hundred years after the State of Pennsylvania first surveyed a projected railroad, the State Legislature created a turnpike commission to build and operate a four-line toll road between Harrisburgh and Pittsburgh.

It is now nearly ready for traffic. Indeed on some sections, vehicles are running, and part of it was used during recent manœuvres by the National Guard. If William H. Vanderbilt could see this amazing development he would be staggered, for it is greater than anything he ever conceived.

The road has four lines for traffic, the up and the down routes well separated by a grass strip. Wide sweeping curves preserve speed. There is no gradient steeper than three per cent—one in thirty-three. All cities and towns are by-passed.

More earth was moved about than in the construction of the Maginot Line, a total of 26,000,000 cubic yards. No fewer than 139 bridges were built, in addition to widening seven of the original tunnels.

Twenty-six highways and four railroads had to be crossed, and this was done by tunnels or bridges, so that there is no intersecting traffic and no traffic lights or level crossings.

Feeder roads join on the German autobahnen plan, running parallel for some distances with the speedway, so that the traffic can merge easily. To avoid ice and snow, southern and western slopes of the mountains were used.

The road is below the fog line and allows the possibility of flooding. And it is estimated that in its first year of operation no fewer than 1,300,000 cars and trucks will use the new highway.

For their service and convenience a subsidiary enterprise has been established. The Standard Oil Company of America obtained exclusive rights for twenty-five years to provide fuel and other facilities along the speedway.

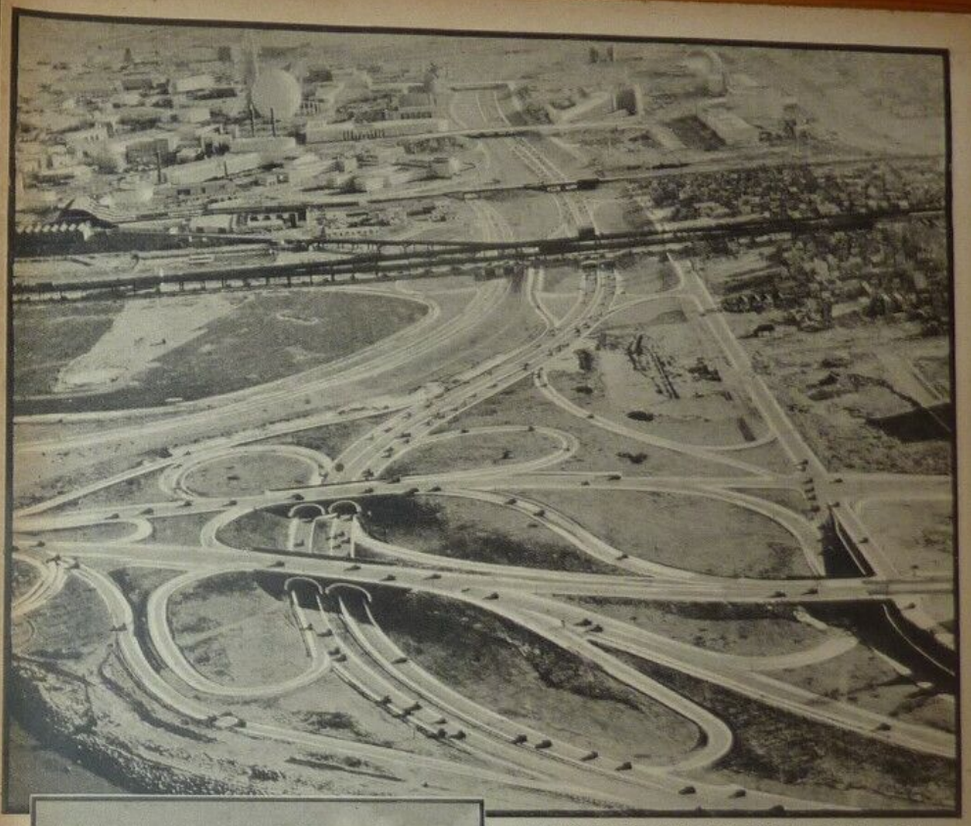
Ten Esso service stations have been built along its hundred miles, locations being staggered so that there is one every fifteen miles. One of these, placed halfway, has a two-story building. The other nine stations have a single story, the architecture following early Pennsylvanian design.

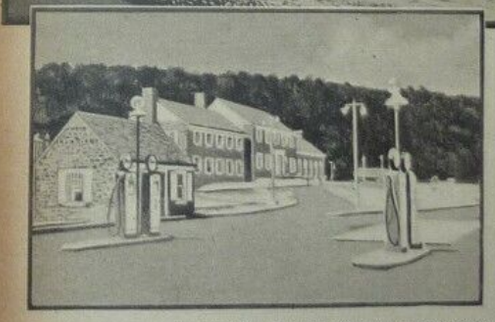
Each service station has asphalted accelerating and decelerating lanes 1,000 feet in length, so as to provide drivers with safe and easy exit from, and entrance to, the high-speed highway.

The midway station, which is the one with two buildings of two stories, has a new development, for it separates commercial vehicles from private cars.

Entering from the decelerating lane, passenger car drivers find a parking place which will hold thirty-seven vehicles. They drive round the front of the buildings to the islands, on which are the oil and petrol pumps.

Drivers and their passengers entering from the front will find attractively decorated lounge and rest rooms, dining-rooms and a terrace providing a fine view of the mountains.





(*Above*) **Problems of avoiding interference with the stream of traffic are being solved by the experts.** Fly-overs and intricate one-way systems were a feature of the roads surrounding the recent New York World Fair. (*Left*) **Service stations are erected on the new express highway at approximately fifteen mile intervals. Decelerating lanes are provided and ample room is made for parking and fuelling.**

Drivers of trucks, leaving the decelerating lane, drive to the rear of the station to a parking place specially provided for them. The service islands supply two grades of petrol, and an Esso-Diesel pump, for vehicles running on heavy oil, capable of delivering twenty-five gallons per minute instead of the usual twelve to fifteen.

As some lorries convey valuable cargoes, there is a special building where they may be housed. Truck and coach drivers have their own lunch room, smoking lounge, thirty-eight bed dormitory and shower baths.

There is, of course, every kind of service facility available for Americans specialize in this. The midway station is placed on the eastward-bound side of the highway.

On the westward-bound side there is a small station for quick service, connected by a tunnel under the roadway to the main station should other facilities be required.

Oil and petrol are brought in pipe lines to various bulk stations and then conveyed by road tankers of a special design, the main object of which is safety, particularly from risk of fire.

Very shortly motorists will be using this express highway. They will pay a toll of $1.25 to $1.50 (5s. to 6s.) for each complete journey, or for shorter sections at approximately one cent per mile.

Commercial vehicles pay a higher rate according to weight, varying from $4 to $10. It is considered that the reduction of petrol consumption, engine, brake and tyre wear, and the shortened running time will readily compensate for the toll.

It is a top-gear road all the way. Formerly, routes over the Pennsylvania mountains necessitated climbing 10,000 feet, with many steep ascents; but these are now abolished. Curves are long and gently sweeping and carefully banked.

Visibility extends for a great distance and is never blocked by sharp turns or steep grades. There are only ten points at which, by means of clover-leaf intersections, this super highway can be entered or left.

There are two wide lanes up and down, separated by a central grass plot. The original railway tunnels had to be doubled in width to accommodate these lanes.

Speed has been in the forefront of the engineers' planning of this highway. They say that it will be safe for 120 m.p.h. with a little slowing down at the curves and tunnels.

It is anticipated, notwithstanding that this will be the fastest road in any considerable length in the world, that it will also be the safest, because almost every possibility of an accident has been eliminated.

Apart from private cars, fast motor coaches will beat the highest speeds of the crack American trains.

This is only one of a series of special motor roads to be constructed for a new and faster era of travel in U.S.A.

It makes you think, eh?

(Reproduced by permission of "The Motor")

WORLD'S LARGEST X-RAY

MIGHTY NEW MACHINE TO SERVE MEDICAL WORLD

GENERAL ELECTRIC is building for the National Bureau of Standards one of the highest voltage X-ray tubes ever made, a multi-section giant twenty-eight feet six inches long, to operate at 1,400,000 volts.

At the same time, one of the most powerful constant-voltage, direct-current generators ever made is being built to operate the tube. The complete equipment will be used for research work in the high voltage field. X-radiation roughly equivalent to that of £40,000,000 worth of radium—more than there is now in use in the United States, will be developed by the equipment and in X-ray production this machine will be the most powerful in the world.

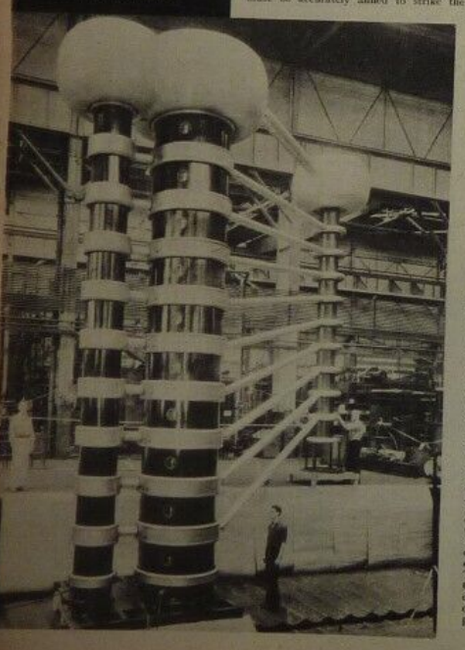
The new device will serve several important purposes at the bureau. The first of these relates to the measurement of X-ray dosage. This will be of value to the medical profession, which has for several years been employing 200,000-volt X-rays in the treatment of cancer and other diseases, and has recently been extending its work in this field to higher and higher voltages.

International agreement has been reached on methods of dosage requirements for voltages up to 200,000. The bureau has extended this work up to 400,000 volts and, with the new X-ray outfit, will be able to carry it from here up to 1,400,000, which is in excess of any X-ray voltages now being used by the medical profession.

The same high-voltage generator with another multi-section tube, duplicating in many respects the X-ray tube, can later be used for the production of neutrons and artificial radio-activity. The high-voltage generator can also be used for another important function, namely, to extend the high-voltage measurement work of the bureau to higher levels.

The tube is rated at 1,400,000 volts and ten milliamperes, and is composed of ten sections of 140,000 volts each. The tube is mounted vertically and the envelope, consisting of ten glass cylinders placed end to end, will be mechanically shielded against breakage for its entire length with a strong envelope of insulating material. The electron beam, which will travel twenty-four feet from the cathode at the top of the tube to the target at the bottom must be accurately aimed to strike the target and must be of the proper size.

An electron gun. The new 500,000-volt cathode unit of the Bureau of Standards X-ray machine. From this unit mounted at top of the tube an electron beam hurtles down, attaining speed of 180,000 miles a second. The X-ray machine which radiates the equivalent of 140,000,000 of radium.



For the satisfactory operation of the X-ray tube it is essential that all the electrons leaving the cathode should reach the anode—in other words, that none of them should strike either the glass walls of the tube or the various metal accelerating electrodes. This necessitates not only starting the electrons all out in the right direction, but guarding them from the deflecting action of external electrostatic or magnetic fields. It also necessitates the attainment throughout the length of the tube of a high degree of symmetry about its axis.

The construction of the tube permits a unique method of applying energy to the electron beam after leaving the cathode. Starting at zero velocity the beam is accelerated through the first section of the tube to 140,000 electron volts velocity. As it enters the second section, it receives an additional voltage kick of 140,000 which still further increases its velocity.

Process is repeated through each section of the tube so that when the electron beam finally reaches the target, it has the velocity and the energy which it would have had it been given a single 1,400,000-volt kick. Its speed is about 180,000 miles a second or very nearly the velocity of light.

The tube may be operated at will at any lower voltage down to 300,000. This flexibility is important for the research work to be undertaken. The high-voltage generator furnishing power to the tube is likewise an unusual piece of equipment.

It is composed of step-up transformers, capacitors and kenotron rectifier tubes. There are ten sections, each rated at 140,000 volts, connected individually to the ten sections of the tube and producing a total of 1,400,000 volts. The generator forms a stack thirty-two feet high and five feet in diameter. It provides a very constant potential supply to the X-ray tube.

With it is a stack of resistance units of like height and external appearance, but only two and a half feet in diameter. These are used in measuring the voltage. Over the tops of the two stacks will be a corona shield to prevent the discharge of electricity which would otherwise take place in the air.

This is made of spun aluminium with a maximum diameter of twelve feet and a depth of four feet. Another corona shield surmounts the top of the X-ray tube proper. Around each section of the generator and each section of the tube, doughnut-shaped corona shields are also placed.

Three of the ten sections of the tube which each accelerate the beam 140,000 volts. Spun aluminium is used for the corona shields, which have a diameter of 12 ft. and depth of 4 ft. Shields at top of tube prevent discharge into the air.

The equipment will be housed in a special building now being erected and will be delivered soon.

The present transformer equipment is being built in the Pittsfield works of the company and the X-ray tube in the research laboratory in Schenectady.

The tube design is an extension of that of the 800,000 and 1,000,000-volt tubes installed in various hospitals.

As the world's largest X-ray apparatus goes into service, new fields of research and knowledge are certain to open up. The tremendous potential X-radiation available with this new machine will no doubt spell greater progress.

TROOPS FROM THE CLOUDS

A NEW INSTRUMENT OF TOTAL WARFARE IS THE TROOP CARRYING PLANES POSSESSED BY BOTH BRITAIN AND GERMANY

THE days of the foot-slogging soldier are over; they ended abruptly in November, 1918. The advent of mechanized transport, light tanks and armoured cars and above all the aeroplane has brought about a new kind of warfare; trenches and positions are not, now, so important—the new warfare demands speed.

The invasions of Holland, Belgium and France have shown that the speed with which it is possible to transport troops, arms and supplies has a direct influence on the course of the battle. The menace of parachute troops has proved to be no myth and in the Russian occupation of Bessarabia light tanks were dropped from transport aircraft. Aerial transport for men and machines has come into its own after its first baptism of total warfare.

Aerial troop transport is something comparatively new to Germany. Her parachute troops, copied after the Russian model, materialised only a few years ago and are still her most important air-born infantry. During her recent aggressions, however, she has most certainly been using some of her converted air liners and heavy bombers laden with fully-armed troops ready for instant action, in co-operation with her fighting battalions. Britain, on the other hand, has found bomber-transport aircraft extremely useful in helping to police the empire for many years past.

Such famous instances as the evacuation of civilian population from the legation in Kabul during an Afghanistan war when Vickers "Victoria" aircraft evacuated 586 souls with only one mishap after making many return flights during the early part of 1929; and on the occasion when whole infantry battalions were flown from Egypt to Cyprus, to quell internal trouble, and to Trans-Jordan to take care of native tribes; and the frequent flights across the Iraq desert to safeguard British interests and lives, prove conclusively that for many years Britain has realized the value of being able to use her air arm to carry her soldiers. Now, however, like the Germans, for the first time we are faced with troop transport by air under difficult wartime conditions.

The qualities of a bomber-transport aircraft capable of doing really valuable service are identical with those that the designers of a first-class passenger liner considers.

Primary considerations are, of course, number of passengers to be carried, range, low landing speed and, above all, safety and reliability. These last two qualities are perhaps considerably more important than the rest; it is futile to increase the army casualty lists through unsafe transport aircraft.

Low landing speed is another important essential. It is impossible to tell where a transport aircraft may be called upon to make a landing; perhaps in a field covered with bomb or shell craters or in a space with inadequate landing run. High landing speed would be fatal in either of these two cases.

In this respect we are highly fortunate. For many years past the British commercial aircraft designer has always held

Accommodation is provided for twenty-four fully equipped troops and twelve air conditioning tubes project into the cabin to provide a great boon to Tommies inclined to be air sick. The maximum speed is 186 m.p.h. and the range 1,500 miles.

The plane has nearly a 100 ft. wing span and a take-off run of 500 yards, the undercarriage is non-retractable and there are two gun turrets, one in the nose and one in the tail.

Should the aircraft not be required for troop transport there are alternative loads

British troops disembarking from an air transport plane during army exercises.

safety as a vital factor to be taken into account and placed in importance before performance. On many occasions British designers have been laughed at for their slow and apparently clumsy aircraft but neither America nor Germany ever built a plane to compete in safety with Imperial Airways air liner *Heracles*, which flew over 1,000,000 miles and carried more than 100,000 passengers without a single mishap.

Apart from converted civil air liners Britain has one principal bomber transport, the Bristol "Bombay." Despite the fact that this plane was originally designed and flown in 1934 it is still a remarkable aircraft.

With the Westland "Lysander" it is the only high wing monoplane still in production for the R.A.F., but it has been considerably modernized since its first appearance six years ago, notably by the inclusion of better engines and propellers.

consisting of water tanks, very useful in desert country, spare aircraft parts, notably engines, stretchers or fuel tanks. Provision is also made for the aircraft to be used as a bomber with a very useful load.

Germany's troop-carrying aircraft are either adaptations of out-of-date air liners or conversions of her most recent bombers. Among the types of aircraft used at various stages of the war for carrying infantry are Junkers "Ju 52m," trimotor metal aircraft used for many years on the *Deutsch Luft-hansa* air lines, and the "52w," seaplane version of the same machine. These two planes can carry about eighteen troops. The Focke-Wulf "Condor," four-motor planes used on transatlantic experimental flights can carry thirty troops and the Heinkel "He 116" about eighteen troops; the giant and grossly out-of-date Junkers "Ju 90" has a capacity of forty troops. The last mentioned machine is the experimental plane in which accommodation was provided in the wings. Later machines are the Junkers "Ju 88" bomber and the Junkers "Ju 90" bomber, the latter having a capacity for forty-five troops.

Principally designed for parachutists, these machines would not allow their soldier occupants the comfort that is available in the British Tommy in his aerial flight.

Among our own air liners that would serve as useful troop carriers are the Armstrong Whitworth "Ensign," capacity probably between thirty and thirty-five men, the de Havilland "Albatross" capacity about fifteen men and the "Flamingo" carrying about ten men, all of which aircraft are of comparatively recent design with top speeds around and above the two hundred m.p.h. mark.

A breakdown in the railway system or considerable damage to main roads would call upon a large fleet of these troop-carrying planes to whisk men from their depots to confront the enemy in any part of the country, all within a few hours.

While preparing herself, however, Britain is taking good care that the enemy's surprise tactics do not succeed here as they have elsewhere. L.D.V.'s stand guard day and night, possible landing fields have been made impossible by the use of pits and poles and, most important, the whole population of Britain is on the watch.

The outcome of this urgent necessity for aerial troop transport will be even greater co-operation between the army and the air force and the arguments in favour of the army possessing its own air force will no longer exist while the R.A.F. remains intact. Co-operation between these services will bring about better understanding and urge them on to even greater efforts.

NEW NAZI HORNETS' NEST

THE GERMAN AIRCRAFT CARRIER "GRAF ZEPPELIN"

THE first aircraft carrier ever built for the Nazi Navy was launched at Kiel some fifteen months ago, and according to information received is now completed. A second vessel is being built at Kiel. Although it was expected that this ship would be of revolutionary design, the *Graf Zeppelin* is similar to our own ships and is not so large as the *Ark Royal*. She will accommodate only forty aircraft against the *Ark Royal*'s sixty. The German experts had visions of the *Graf Zeppelin* operating in the Atlantic, using her dive bombers against our shipping, but she will never dare to run the gauntlet of the British Navy's ceaseless vigilance in the North Sea, and is more likely to remain in the land-locked waters of the Baltic where we show her exercising with the latest type Junkers dive bombers with which she will be equipped.

She is a vessel of 19,250 tons with a speed of thirty-two knots, and carries sixteen 5.9-in. guns, ten 4.1-in. anti-aircraft guns and twenty-two smaller ones. How she will fare in a big sea with this heavy armament remains to be seen.

This is the first detailed drawing to be published of her and is exclusive to *Modern World*.

Cross section of the *Graf Zeppelin* showing her orthodox method of side uptakes to funnel. 1, Funnel on starboard side; 2, flight deck; 3, upper hangar deck; 4, lower hangar deck; 5, uptakes on starboard side; 6 and 6A, oil fuel tanks; 7, 8 and 9, boilers; 10, double bottom.

The latest type of Junkers "[illegible]87," the German dive bombing equivalent of our Blackburn "Skua." An unusual feature is the installation of "diving brakes" fitted to the leading edges of the wings. A large 500 k.g. bomb is also carried beneath the fuselage.

KEY TO PARTS

1, New type bulbous bow or wave resister; 2, narrow cut-water; 3, rounded bows with bollard; 4, port anchors; 5-5A, 4.1-in. anti-aircraft guns; 6, steam jet for wind direction; 7-7A, impulsers or catapults; 8, flight deck, 790 ft. long by 88 ft. wide; 9-9A, multiple machine guns; 10, forward aircraft lift; 11, forward 5.9-in. guns; 12, superstructure; 13, conning tower; 14, rangefinder; 15, aa cabins and navigating bridge; 16, fire control top; 17, 4.1-in. anti-aircraft guns; 18, amidships aircraft lift; 19, after 5.9-in. guns; 20, overhanging stern; 21, wireless mast lowered; 22, port propeller and rudder; 23, port 5.9-in. gun turret; 24, boats stowed; 25, fans; 26, boat deck; 27, auxiliary diesel engines; 28, port engine room and turbines; 29, after boiler room; 30, air lock; 31, wing store; 32, lower hangar deck; 33, upper hangar deck; 34, stokers' wash place; 35, auxiliary machinery; 36, forward boiler room; 37, oil fuel tanks; 38, dynamos; 39, petrol tanks; 40, aero-engine shop; 41, aircraft lifts; 42, port 5.9-in. gun turrets; 43, machine shop; 44, seamen's mess; 45, seamen's mess; 46, ammunition trunk; 47, sick bay; 48, main armour belt.

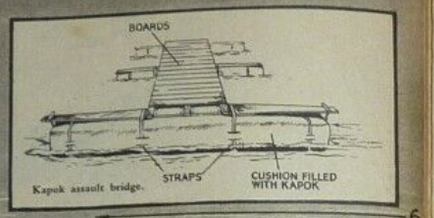
ARWELL WOOD

BRIDGES BUILT IN MINUTES

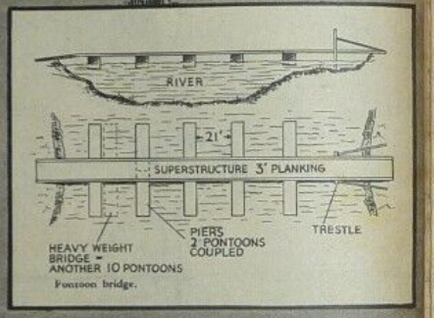
Pontoon rafts which are used as the foundation for bridge building, have other uses where a load is required to be conveyed across a narrow strip of water. By means of skids a heavy lorry can be run on to these flat-bottomed boats drawn up close to the bank, and the sappers can ferry across. The picture above shows a fully-loaded lorry being run on to this simple type of floating bridge.

This picture shows how the pontoons are arranged with a tracked raft across them so that the heavy weight can be transported. When the lorry has been driven on to the pontoons sappers manhandle the floating bridge from the shore, after drawing up the skids so that they prevent movement of the load.

Across the river the lorry is run ashore. It is loaded with kapok floats and trench boarding for building assault type of bridges. This kind of bridge is suitable for handling light loads, chiefly infantry travelling in single file, but the quick erection of this simple type of bridge often allows troops to take a short cut.



Kapok assault bridge.



Pontoon bridge.

MILITARY bridge building is a skilled trade with a very long history. Xerxes crossed the Hellespont on a roadway which consisted of planks laid on lines of supporting boats. More recently bridges have been thrown across rivers, to give passage to advancing troops, which have consisted of barrels or empty petrol tins lashed together so that they supported planks of timber. For military purposes two main types of bridges have to be provided by the sappers, depending upon whether proper equipment is available or improvised methods have to be used.

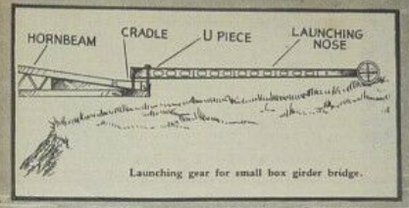
During the Great War there were many occasions when the Royal Engineers had to bridge gaps without proper equipment. Hastily collected timber was made into rough trestles and men and transport were carried over bridges which could only be expected to provide temporary lines of communication. But these were only emergency measures. Our sappers are considered to possess the finest bridging equipment of any army in the world, and it is the regular methods of construction that we shall outline in this article.

Six main types of bridges are employed, three of which rest on the surface of the water, and three of girder pattern, which can be quickly thrown across a gap. The former floating types are naturally lighter to transport, but cannot support so great a load. Materials for the pontoons must be easily manhandled, and depending on the weight to be carried the material required by the bridge building sections is either simple or elaborate.

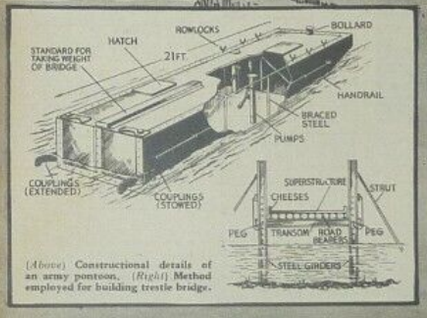
The assault type, which is the simplest kind and used for transporting infantry in single file, consists of kapok filled floats, which are put on the surface of the river and covered with trench board. In actual practice special equipment is kept for the purpose. This consists of canvas floats stuffed with kapok, each of which has a metal plate attached to it so that the wood boards can be easily fixed. Handles on the floats allow for erection of the bridge on the bank of the river, and when completed two men on each float carry it to the water and launch it in a very short time.

Collapsible boat equipment is the second method of providing a speedily erected bridge suitable for transporting medium weights of from five to nine tons, such as light tanks. Quick assembly under enemy fire makes this type of bridge very useful when lines of communication have been destroyed, and the fact that the boats can be rafted into position makes construction comparatively easy to the skilled craftsmen.

FOR BRITAIN'S MARCHING ARMIES



Launching gear for small box girder bridge.



(*Above*) Constructional details of an army pontoon. (*Right*) Method employed for building trestle bridge.

Third type of pontoon construction is known as the regular pontoon equipment. This method is suitable for loads up to thirty tons, but a column of lorries is needed to bring it up to the site, and fairly good approaches have to be provided.

Equipment for this type of construction necessitates three essential parts. Wooden pontoons weighing about 1,400 lb. each and twenty-one feet in length are anchored at intervals across the river with their keels in the direction of the current. Cross beams link the pontoons, and planks are laid across these to carry the roadway. Four methods of building are employed. The simplest adds successive stages as the pontoons are ferried into position and the roadway laid, until the river has been spanned. Another method is to build the bridge and gradually push out each stage as erected until the further bank is reached. Again complete sections may be assembled on the bank, floated into position and connected together. The last method is to assemble the sections along the bank of the river and allow the current to swing it into position when the work is completed.

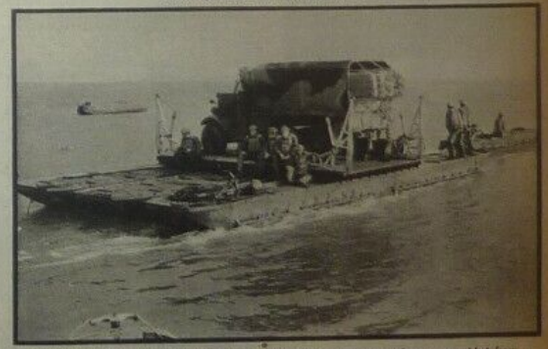
For more permanent types of bridges, capable of carrying heavier loads, there are three girder kinds. The lightest will span sixty to seventy feet, is very easy to handle, carries a considerable load, and can be quickly erected by cantilever launching. A heavier type which will span gaps up to 120 feet is still sufficiently easy to handle that it can be erected under gun fire. The girder type proper is suitable for any load. Much more of a permanent construction, this kind takes four to eight days to erect. The sections from which the building is done consist of skeleton steel boxes made up in girder form, which are connected together according to the distance to be spanned.

This type of construction lends itself to the building of any required length or width of roadway. Methods of launching may be either by cantilever or derricks. When cantilever launched, each girder is used as a counterweight for the next, the last being rolled into position.

Not only do the sappers have to construct bridges for the passage of troops and materials, but their training prepares them to repair damaged ones that are shelled by the enemy or left behind by a retreating foe. One problem that often takes considerably more time to overcome than the actual construction of a bridge is preparing an approach road. For the lighter types of bridges this difficulty does not arise, but for the girder semi-permanent kinds roads must be built or strengthened so that they can carry heavy mechanized transport.

Girder bridges are assembled when semi-permanent construction is required. They carry much heavier loads, and there are three kinds, according to the weight to be transported. Four principal methods of erection are employed, and one way, which is being employed in this picture is to push out sections as assembled.

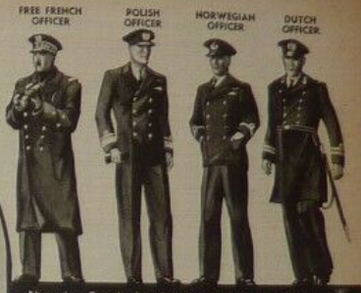
As the small box girder bridge has been slung across a gap, sappers lay the decking across it, ready for transporting troops or light mechanized units. For permanent bridges larger girders are used and proper road approaches have to be built. Construction of these heavy types takes four to eight days, and they will carry any load.



For ferrying loads over a greater distance more elaborate pontoon rafts are assembled from bridge building equipment. A motor boat is used to tow the raft, and considerable success is obtained by this method of transport so long as there are no fast-running currents to combat. A special platform is lashed to the deck of the pontoons.

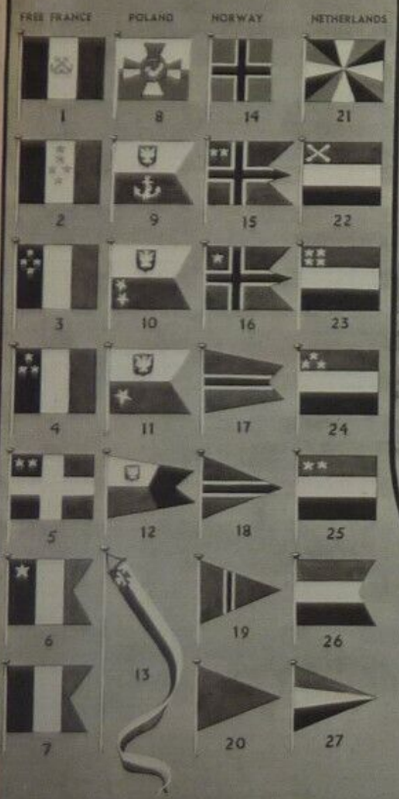
OUR ALLIED FLEETS

The Free French forces wear the same uniform as the original French naval personnel. The French seaman's hat and plain white front to the collar make him distinctive. Polish uniforms resemble the British. The hat shown is similar to American sailor's but is only for shipboard use. The Norwegian sailor has distinctive head-gear. The vest is striped similar to the French. The collar is worn high, with black scarf under tied into a knot. The Dutch sailor is in ceremonial rig. Note cap and short jumper.



Above is a French vice-admiral in greatcoat. He carries his rank on the sleeve of the greatcoat. The hat makes a French naval officer easily recognizable. Polish officers follow closely the British pattern, although the sleeve markings are different. Three stars are worn under the cap badge which is an eagle and anchor surrounded by oak leaves. The Norwegian sub-lieutenant's uniform is similar to the British but cap badge is in plain gold. Dutch naval officers wear an anchor on the collar.

FLAGS OF THE ALLIED NAVIES



Above are the different flags of each of the allied fleets. They are: FREE FRENCH FORCES: 1. Jack; 2. vice-admiral; chief of staff; 3. commander-in-chief (vice-admiral); 4. vice-admiral; 5. rear-admiral; 6. captain in command of a division; 7. captain in command of a force. POLISH NAVY: 8. Jack; 9. Chief of naval department; 10. vice-admiral; 11. rear admiral; 12. commander of a division; 13. commission pennant. NORWEGIAN NAVY: 14. Jack; 15. vice-admiral (admiral has three stars); 16. rear-admiral; 17. squadron commander not of Admiral's rank; 18. divisional commander; 19. pennant of seniority; 20. warrant officer in command. ROYAL NETHERLANDS NAVY: 21. Jack; 22. admiral of the fleet; 23. admiral; 24. vice-admiral; 25. rear-admiral; 26. captain commanding a division; 27. senior naval officer (flown from yard-arm). In the above black represents dark blue and red is represented dark grey. These are the flags that now fly for victory in the cause of democracy.

SOME fine ships have joined forces against the Axis Powers. They include modern and revolutionary designs.

From almost every country over which Hitler's hordes have poured during the past year Britain has gained new allies in the struggle for democracy and freedom. A year ago the names of Holland, Norway, Belgium, Denmark were marked as neutrals on the map of Europe — today those countries, although temporarily conquered, are Britain's allies.

On these pages we illustrate some of the aspects of the Allied Navy, fighting alongside the Royal Navy in home and overseas waters.

Consisting of units which escaped from Holland, Norway, France and Poland, the allied fleets are made up of men who rather than subject themselves to Nazi rule, have endured many perils in making their way to British ports to continue as a fighting unit against the mutual foe.

Who can forget the heroic exploits of the Dutch submarine Orzel, chased all over the North Sea, bombarded with depth charges, grounded under water yet still coming through to serve as a useful component of Great Britain's under-sea striking power.

Then there were the three Norwegian officers who raced the North Sea in a small sailing boat and succeeded in their desperate attempt to reach Britain and fight again.

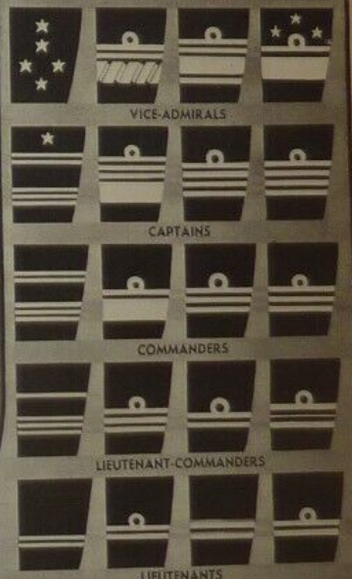
Frenchmen rather than surrender to the enemy escaped in their ships, or made their way overland, to serve and fight against the common enemy and contribute towards the liberation of their country.

All these men are now serving with the Allied Navy.

Battleships, cruisers, destroyers and escort vessels along with some submarines are now working as units co-operating in the manifold tasks being carried out by our own navy. Many have already been in action and have joined battle with the enemy. Many more are carrying out those humdrum, silent jobs for which the Navy's efficiency is famous. These are releasing units of our own navy to join squadrons in distant seas for the thorough protection of British trade routes.

By forcing their countries into submission Hitler has made many new allies—for Britain.

RANKS IN THE ALLIED FLEETS



Above are the principal officer ranks for each allied navy. Admiral's markings are similar to vice-admiral's but carry an extra star in the French, an extra stripe for Polish and Norwegian, and crossed batons in place of stars for Holland. A French commander's stripes are two silver and three gold. The Norwegian and Dutch are like the British. With the exception of the French the rank of lieutenant is the same as the British. Above are their hats which show the details to recognize: 1. Free French naval forces; 2. Polish. 3. The Norwegian hat has a house on top and a small disc with red, white and blue worn on front. 4. The long cap ribbon hanging down at the back of the hat denotes the Dutch navy. We wish them all good hunting of the common foe.

S.S. Jacona, a converted last-war ship, which generates 20,000 kw. This floating steam-electric power station is kept on the river near Portsmouth, New Hampshire, for supplying current wherever needed. Two 10,000 kilowatt generators are used.

CITIES LIT BY MOBILE GENERATORS

FLOATING POWER HOUSE TO SOLVE PROBLEM OF "BLITZED" TOWNS

By
B. TUNBRIDGE

SHOULD American cities suffer bomb damage like London and Coventry, electrical experts have ready plans that will help them to maintain essential current and keep factories operating and houses lit.

The idea is to provide giant floating power plants, capable of generating 50,000,000 watts of electricity.

Enemy warplanes attack electric supply plants as one of the most important military objectives. Upon continuous operation of the generators depends the life and productiveness of the community, and railways and all kinds of machinery, to say nothing of most domestic amenities, come to a standstill when the current is switched off.

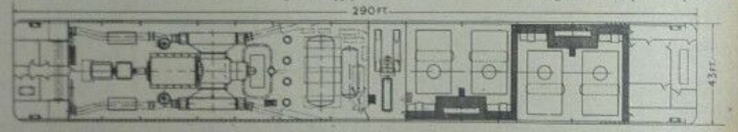
A direct hit scored on one of these giants is a bull's-eye for the raiding airmen for it holds up vital work and disorganizes the life of the town.

In wartime production is the life-blood of a nation. Most manufacturing is geared to an uninterrupted supply of electrical current, and without it the best mechanic is helpless to carry on with his job. That is why any plans that enable a breakdown to be quickly rectified are of real interest in these days of intensive air activity.

Bitter experience has demonstrated how a few bursts of raining bombs can upset normal life, and some of the American cities whose generating capacity is dependent on water supply have known the inconvenience of "lights out" through nature failing to provide the source of power.

The new plan for mobile generators is no mere flight of fancy. A first experiment with a floating power plant was made in 1929. In that year the city of Tacoma, Washington, was so short of water that there was insufficient to generate the town's supply of electricity.

At that time there were no specially built boats for producing electrical current. Instead, the United States battleship *Lexington*, which is driven by electric turbines, was hitched up to the power lines of the city, and continued to supply the town's needs until water was once more available.



Plan view of the turbine deck of the proposed 50,000 kilowatt vessel which, it is suggested, should be built under the American defence scheme. It will be valuable for feeding factories erected in out of the way places.

Such a bright idea for solving the needs of a community hit by the "blackout" of its electricity was far too good not to be followed up. An electrical supply undertaking in New Hampshire saw the possibilities and set about adapting a special vessel to serve the purpose.

Obtaining a last-war ship called the Jacona, they set about converting it to its new job. They fitted it with two 10,000-kilowatt turbine generators, and made it onto a first-class floating steam-electric power station.

This mobile power station is kept on the river near Portsmouth, New Hampshire, and is available for any emergency that may occur to electric supply undertakings in the State.

The success of this early experiment has encouraged the experts to plan bigger floating power stations. With America's present defence needs it is possible that a large ship capable of supplying 50,000 kilowatts of electricity would be valuable for a large number of purposes.

It might be desirable to have a large power supply available at some isolated point on river or coast, and in this case the floating supply plant could be moored at a convenient point, avoiding the necessity of running long lines from a distant power supply.

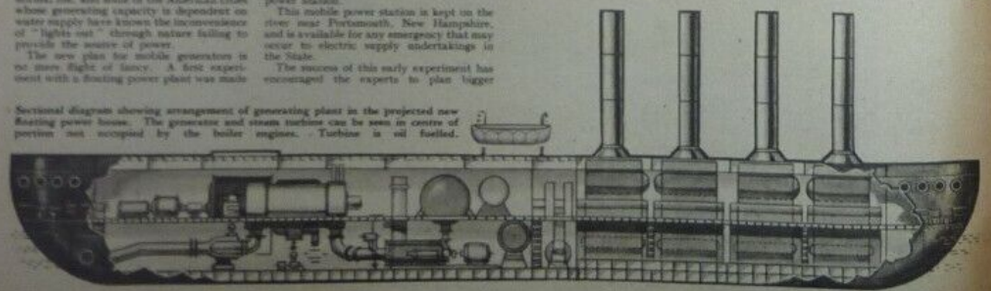
The projected ship for the purpose will be about 290 feet in length, with beam of forty-three feet and ten-foot draft. As the ship may have to pass beneath low bridges, clearance will be low.

Oil-fed steam turbines would drive the main generator, and the boat would be capable of moving about under its own steam. Cables from the stern of the vessel run ashore and connect with the overhead lines of the existing town supply, or tie up direct to the machines where no supply exists.

Besides its usefulness as an emergency unit the floating power plant would be invaluable should national needs suddenly require the erection of manufacturing plants in out-of-the-way places. The ship could start the factory in operation whilst a permanent power plant was being erected.

As an example of emergency producing an important new development in scientific progress, the hitching of the *Lexington* to Tacoma's electricity wires is excellent. Had there been no shortage of water to drive the generators a special ship would probably never have been built, and the plans which may prove of great help in America's defence drive might never have been thought of.

Geographically the vast continent of America is more suited to such experiments than our inland home. Extremes in climate make sources of power for generating electricity less reliable, even in peace time, but such mobile power plants have real value for limiting the ravages of man and nature.



Sectional diagram showing arrangement of generating plant in the projected new floating power house. The generator and steam turbine can be seen in centre of portion not occupied by the boiler engines. Turbine is oil fuelled.

FARM FITNESS GUARDS YOUR HEALTH

RESEARCH WORK OF BIOLOGISTS AND VETERINARY EXPERTS RUN ALONG PARALLEL LINES

SCARCELY a day goes by without the story of some new development in medicine or surgery being reported. Ceaselessly our doctors are labouring to improve the health of the human race, and, in reading of their efforts we are liable to forget that animals, too, have their champions who work for their betterment.

In America the Bureau of Animal Industry has been working since 1884 to improve the animal kingdom. Farmers and stock-breeders all over the United States look to the Bureau for help and advice, but it was not always by any means such plain sailing.

When the Bureau was established, its first and greatest fight was against prejudice and superstition.

One old farmer in New York State killed every one of his cows rather than allow a veterinary surgeon to administer a tuberculin test; inspectors of the Bureau have been menaced with shot guns and dipping vats have been dynamited.

In the face of such unreasoning prejudice the Bureau might well have been forgiven had it decided to give up the fight it was waging in the interests of the animal kingdom. But as it was, those pioneers fought back with a stubborn determination that won through.

Research Benefits Man

And well it was that they did so, for their research work has proved of inestimable value not only to the animals themselves but to the human race.

For instance, it is thanks to the Bureau's experts that such important pharmaceutical extracts as insulin, thyroid and pepsin are all taken from healthy animals.

Milk, too, is now amazingly free from infection in America. Statistics compiled by the Bureau show that although half the milk consumed there is not pasteurized, cases of bovine tuberculosis contracted by drinking infected milk are so rare as to be almost non-existent.

Unfortunately, Great Britain has still a long way to go before she catches up with America. Indeed, only a few years ago, a quarter of all cases of non-pulmonary tuberculosis were traceable to infected milk.

Veterinary work in the United States appeals to many young men, but they are hampered in that schools of veterinary medicine have to turn away thousands of applicants owing to lack of accommodation.

In fact, despite the ever-increasing realization of the vital importance of this type of work, a recent census showed that there were no more than thirteen physicians to every 20,000 animals.

It is no easy matter for the student to be accepted as a member of the staff of the Bureau, for a very high standard of knowledge is rightly demanded. Thus, subjects which must be mastered include pathology, bacteriology and materia medica.

Animals Pass on Disease

Some idea of the work already achieved by the Bureau may be gathered from the fact that of the thirty-five worst diseases to which livestock are prone, no fewer than eleven are now totally absent in America.

And a rigorous watch of all livestock entering the country ensures that these diseases are not reintroduced.

America has for long raised hogs on a vast scale, but for many years the industry struggled against the great handicap of hog cholera which did damage to an average annual extent of £10,000,000.

Today, thanks to the scientists of the Bureau who produced a preventative serum, such losses are down by at least sixty per cent, and are still falling.

Much of the scientific research work carried out by the experts is of a highly complicated character. This is largely due to the fact that entirely different types of animals may have certain diseases which are common.

Thus the task of cornering any one virulent disease and then proceeding to stamp it out is most difficult.

For instance, although swine are the only creatures to contract hog cholera, they are also susceptible to avian tuberculosis, which chickens contract, and to bovine tuberculosis.

Much of the research work performed by members of the staff of the Bureau of Animal Industry has a direct bearing on the health of men and women as well as of animals. And often the result of one discovery in the field of veterinary science has most important sequels for the human race.

Controlling Epidemics

When Theobald Smith, one of the Bureau's workers, succeeded in proving that the dread cattle fever which cost breeders vast annual sums, was transmitted by ticks, he took a big step forward in stamping out the disease. But he did more than that.

Thanks to his initial discovery, the great scientist Walter Reed, who was seeking for the source of yellow fever, suddenly realized that this, too, might be transmitted by an insect. Then he was on the high road to completing his task of tracing it back to the mosquito.

In the same way, it was from knowledge of Smith's research that both bubonic plague and typhus fever were ultimately found to be carried by fleas.

One branch of the Bureau's work is devoted to control of those epidemics that ravage herds and wild animals from time to time. This is not done merely from humanitarian motives, although that naturally enters into things.

Both wild and domestic animals use the same pastures, and if the former are infected, there is all too strong a probability that the valuable domestic animals will contract diseases which will result in considerable loss of life and money before the particular disease can be got under control.

War on Pests

In the same way that wild animals can infect domestic ones, animals of many types can infect humans. Thus, it is no wonder that the research work of the biologist and the veterinary expert often ran on parallel lines.

One of the most important discoveries made during recent years was that the American grey squirrel was subject to bubonic plague.

The fleas hiding in their coats were the carriers which could convey it to humans, and when once the discovery had been made, the Government declared war on the grey squirrel.

It was vitally necessary for them to be put down ruthlessly that men, women and children might be freed from the terrible risk of plague.

It is due very largely to the research work of the veterinary that many ills to which human beings are prone have been traced back to animals. Thus typhoid, diptheria and smallpox, to say nothing of tuberculosis and even septic sore throat, are spread through milk given by diseased cows.

And among the diseases which are common to man and to animals are anthrax, rabies and glanders.

In America, the Bureau is determined that farmers shall be given every opportunity to appreciate the help it can give them, and a very large publicity department maintains close co-operation by means of booklets, pamphlets and even instructive films.

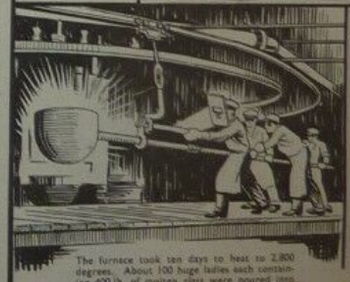
Thanks to the tireless work of the Bureau of Animal Industry, American livestock breeders are now more successful than ever.

MAKING GIANT TELESCOPE MIRRORS

The world's largest telescope mirror at Mount Wilson Observatory, Pasadena, California, is 201 inches in diameter by 25 inches thick and weighs 18 tons. When cast it measured 26 inches thick and weighed 20 tons. Grinding and polishing alone occupied two years and it is accurate to one millionth of an inch. Stars reflected in it are 250,000 times as bright as they appear to the naked eye. It is estimated that some 200,000,000 stars can be observed through this wonder telescope as compared with a mere 5,000 visible to ordinary human vision. The clean, dry air on Palomar Mountain affords conditions for observation that are essential if the glass "monster" is to yield best results.

Diagram of a Cassegrainian telescope showing principles of the Mount Wilson telescope.

Casting mould fitted with dome shaped electrical heating devices to ensure maximum temperature and provide weight-saving recesses in the casting. The mould was heated to a temperature of 2,400 degrees before pouring in the glass. Before casting 4½ tons of material were melted each day for 15 days.



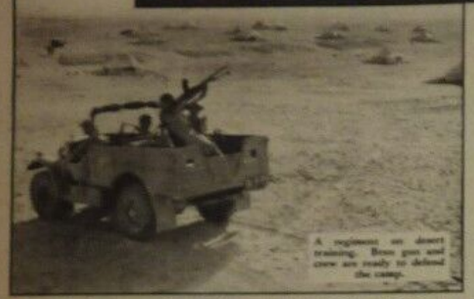
The furnace took ten days to heat to 2,800 degrees. About 100 huge ladles each containing 400 lb. of molten glass were poured into the mould continuously for twenty-one days, a total of 75,000 altogether. Rate of cooling was from one to two degrees daily for twelve months.

Galileo's first telescope magnified only three diameters. The Mount Wilson magnifies 250,000 diameters.

At the end of a year the glass had cooled and was then ready for examination. When the annealing cover was lifted, to all appearance the disc was perfect but it was subjected to intricate tests before experts were satisfied that it was unblemished. A special crate was constructed and the precious disc transported to California.

Although the largest mirror in the world at the present time, astronomers are already dreaming of reflectors double the size which will reveal the stars not as tiny pin-pricks but as definite discs, in spite of the fact that such increase in weight would present almost insuperable difficulties in cast and erection.

ISLAND FORTS of the DESERT



A regiment on desert training. Bren gun and crew are ready to defend the camp.

Like a giant spider's web, a camouflaged Bren gun post guards the desert.

STANTON HOPE describes isolated outposts guarding the sandy wastes

WAR is a severe schoolmaster, and one of its easier teachings is geography. Sometimes, places not to be found in any ordinary atlas become world-known owing to the spread of hostilities, as recently was the case of Moyale, an outpost on the Kenya frontier and scene of heroic fighting against hordes of Italian troops.

Since Mussolini, hypnotised by Hitler's spectacular successes in France, decided to add Iran to the European bonfire, he has managed to light up fresh frontiers for our interest. For the flames of war have spread through North and North-west Africa from the Mediterranean to the Indian Ocean.

A full moon and countless stars quangle the African sky, flooding the scene with a pale white light. We move silently forward from the Egyptian side toward that perilous border, marked by no dotted line or other signposts. We traverse the flat ground, familiar to British patrols, and find no difficulty in locating the frontier. Potential raiders are warned that they may come "thus far and no further," and the Italians have signified to this by a barbed-wire barrier that extends two hundred and fifty miles southward from the coast.

Cunningly concealed machine-gun posts and armoured-car patrols are two other methods for keeping that frontier inviolate. Yet, from the first days of the war with Italy, gallant British troops cut the wire at various points and trickled through to capture Italian barrack posts and harass the enemy despite their being heavily outnumbered.

For years we have been plagued with facts and fancies about the mighty steel underground fortresses of the Maginot Line, that series of defences which proved of no more use than rabbit wire for stopping the Germans invader. But if our conception of a fortress is in the terms of the concealed gun pits and galleries of the Western Front theatres, our first impression may be that the Libyan chain of forts are inadequate and useless. Here on a moonlight night when an enemy attack might be delivered at any time, we are not of these forts owing to picturesque grandeur from the arid plain.

"What a target!" you might say. "What a mark for our artillery and bombers."

We may imagine our airmen and gunners rubbing their hands with satisfaction. This desert fort of the enemy can be seen miles off even at night-time, and it is made the more conspicuous by a structure that looks like the scaffolding for a tower in course of construction. It is really a high look-out post built of steel and manned by sentries day and night.

Outside the walls of the fort are a number of outbuildings used for workshops, garages and other purposes, and which can be evacuated quickly in case of an attack. Otherwise, there is nothing to see except a few date palms, grey with dust in the moonlight, and a rather inebriated row of posts taking the telegraph wires across the Libyan Desert.

But the fort is deceptive in appearance, like the ramshackle motor car of epic in which a famous racing expert put a high-powered 1938 engine for passing everything on the road! The desert fort fairly bristles with modern guns, quick-firing and of heavy calibre. Modern artillery can be slewed almost to every point of the compass from that old-fashioned circular structure mentioned previously. Steel shelters, cunningly placed and camouflaged, shield the crews of anti-aircraft guns able to put up a hot barrage against the raiders of the sky. Howitzers might reduce the solid walls, but heavy howitzers are not suitable for bringing over the lone sand of the desert.

Such a fortress as Capuzzo, which has changed hands twice, has modern ammunition magazines and petrol stores deep under the ground and safe from aerial attack. Garages take the place of the old stables where Arab steeds might have been kept and the compound where riding camels may once have chewed the cud. There are large scuttles and openings in the fort where lorries, armoured cars and light tanks can deploy for raids or enter swiftly in the event of having to make a retreat. Nests of machine guns are manned day and night, and there is no cover for raiding infantry in that flat country except in the difficult conditions of a dust-storm or pitch darkness.

All gun posts, petrol pumps and stores have additional protection from sandbags, which form one of the most useful defensive measures in warfare the world over. All the garrison of a Libyan fort needs is a few thousand bags brought by lorry or dropped from a plane. No mind need be delivered. The troops just shovel the desert into the bags, which are then ready for use.

Italian Libya is nothing like so rich or fertile as French Tunisia, on which Mussolini has long cast envious eyes. But Mussolini can never complain that it has cost him anything for sand for filling sandbags! There are thousands of square miles of great sand dunes, enough to fill sandbags for the next million years!

Distances between the Libyan forts are great, and often the communications are difficult. Water is unobtainable inland except at certain oases, and some of the frontier forts have to rely on water pipelines which have already been bombed and broken by British aircraft. The country surrounding these forts is no picnic ground. The Libyan Plateau, five hundred feet in height, stretches between the coast and the Siwa Oasis, which once was the home of twenty thousand of the warlike Senussi tribesmen.

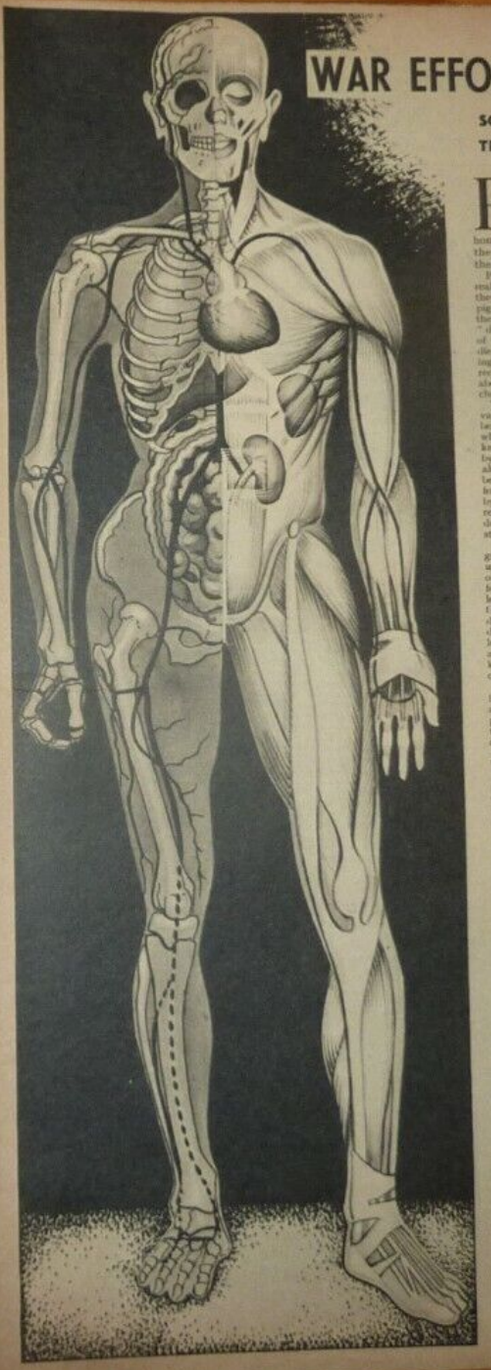
The scenery is rugged, with great defiles between rocky canyons, and everything is covered by the loose dust blown by the south winds from the mighty Sahara. Then away to the south stretch the golden sand dunes of the desert proper, dunes like mighty waves, often over one hundred feet in height. Some of the main Sahara dunes are no less than four hundred miles long by four miles wide.

The native Italian troops, used to scouting among the lesser dunes, have the advantage of the "home ground." They sally forth from the frontier forts in light-armoured vehicles, riding over the lesser dunes where inexperienced drivers would quickly get lost.

The Libyan-Egyptian frontier is a grim place, where ability of the troops to stand the blinding heat counts for much during the summer. Later, when the cooler weather sets in, the forts may come into even greater prominence as full-scale attacks develop around those mediaval-looking fortresses which form the main military posts on that grim desert frontier.

Running sun brings the heliograph home of signalling back into use in desert warfare. These signallers are training to flash messages across the flat sand.

Desert warfare nowadays makes use of modern weapons. British infantry are undergoing desert training, and a trench-mortar crew are seen at practice.



WAR EFFORT of the HUMAN BODY

SCIENCE COMPENSATES FOR ALL WAR DEFICIENCIES THROUGH STUDY OF CHEMISTRY OF THE BODY

PIGS and humans share at least one disease in common. Rickets, which stunts bone and teeth development and results from living in cramped and sunless homes, also attacks the porkers unless they get enough ultra-violet light in their sties.

Pig-breeding countries of Scandinavia realise the importance of ultra-violet and they take precautions by fixing up their pig-sties with special glass which transmits the essential rays. Rickets is one of the "deficiency" diseases; one of the group of afflictions that scourge mankind when diet is ill-balanced. Vitamin D is the missing link responsible for the disease, and recently science has discovered quite a lot about the illusive vitamins and their chemical make-up.

Vitamin D is present in the liver oil of various fish. Butter and the husks of cocoa beans are other sources, but a form of which the chemical constitution is exactly known is called *calciferol*. This is produced by the action of ultra-violet light on an alcohol called *ergosterol*. Vitamin D can be absorbed by eating the right kind of food and thus prevent or cure disease, but by exposing the skin to sunlight, either real or artificial, the vitamins can be produced from *ergosterol* and similar substances in the skin.

In wartime deficiency diseases become a greater menace. Many foodstuffs which usually feature in our diet are difficult to obtain, and there is, of course, a tendency for the standard of living to sink to lower levels than in normal times. During the Great War scurvy, rickets and other diseases caused through wrong balance of diet set the nutrition experts many problems. They set about to discover more about these unclassified vitamins that were known to exist, but about which little chemical data was tabulated.

The research work has discovered a number of very important things. First, it appears that vitamins are organic compounds. The chemical make-up of many of them has been found out, and some of them can be artificially manufactured.

Take, for instance, Vitamin C. With only a letter to distinguish it from the rest of the vitamins, we still knew that lack of it caused scurvy. It is now known to be *ascorbic acid*, and its formula can be written down like any other chemical substance. It is the acid in fresh fruit, vegetables, oranges and lemons.

Because we can now fix its characteristics and know its molecular arrangements we can make it commercially, and Vitamin C today comes out of the laboratory made up from glucose.

Professor Lancelot Hogben in *Principles of Animal Biology* (Allen and Unwin, 7s. 6d.) deals with the chemistry of the body in the section devoted to the sources of energy in the animal body. To the layman biology appears to be a subject which only embryo doctors or individuals of the scientific intelligentsia can hope to understand, let alone find interesting. Yet in the comprehensive study primarily designed for the student, the author has succeeded in producing a volume which creates a fascinating picture of the knowledge mankind has of living matter.

In showing the difference between living and non-living matter he points out how dead matter undergoes little visible change in shape, colour or texture over long periods of time, and certainly doesn't reproduce its kind. Living matter is quite different. It reacts to things and constantly changes position, shape, texture and colour. Then it is receptive to light, heat and other external influences, and is capable of reproducing other life from itself.

Food supplies the source of energy in the animal body, but until it is digested and conveyed to every extremity of tissue together with oxygen from the lungs and carbon dioxide from the tissues back to the lungs, it is of no value. This is where the complicated blood circulation system comes into the picture.

Blood which circulates over the body by way of capillaries, arteries and veins is a fluid having densely packed cells in suspension. The colouring matter in blood is known as haemoglobin, and the application of earlier knowledge relative to it is going to prove of great assistance in treating wartime casualties.

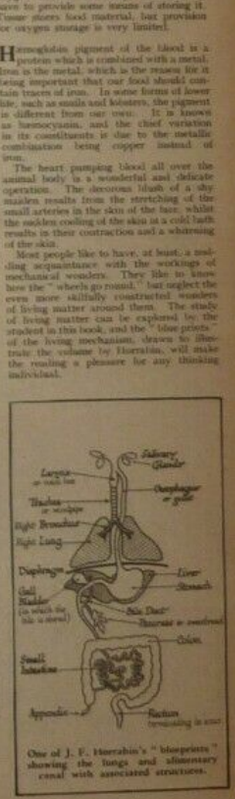
By removing the red corpuscles from blood taken from blood-donors a white liquid, called plasma, remains. To make it more convenient for storage this liquid is reduced to a powder, which can be kept for an indefinite period. Boiling water is added when a transfusion is required, and this stored variety is suitable for most cases which would otherwise necessitate the services of a blood donor.

The red haemoglobin is the constituent of blood with which oxygen combines, and is therefore very important in the transport of essential energy to the tissues. Unless the blood could carry supplies of oxygen all over the body, nature would have to provide some means of storing it. Tissue stores food material, but provision for oxygen storage is very limited.

Haemoglobin pigment of the blood is a protein which is combined with a metal. Iron is the metal, which is the reason for it being important that our food should contain traces of iron. In some forms of lower life, such as snails and lobsters, the pigment is different from our own. It is known as haemocyanin, and the chief variation in its constituents is due to the metallic combination being copper instead of iron.

The heart pumping blood all over the animal body is a wonderful and delicate operation. The decorous blush of a shy maiden results from the stretching of the small arteries in the skin of the face, whilst the sudden cooling of the skin in a cold bath results in their contraction and a whitening of the skin.

Most people like to have, at least, a smiling acquaintance with the workings of mechanical wonders. They like to know how the "wheels go round," but neglect the even more skilfully constructed wonders of living matter around them. The study of living matter can be explored by the student in this book, and the "blue prints" of the living mechanism, drawn to illustrate the volume by Hanrahan, will make the reading a pleasure for any thinking individual.

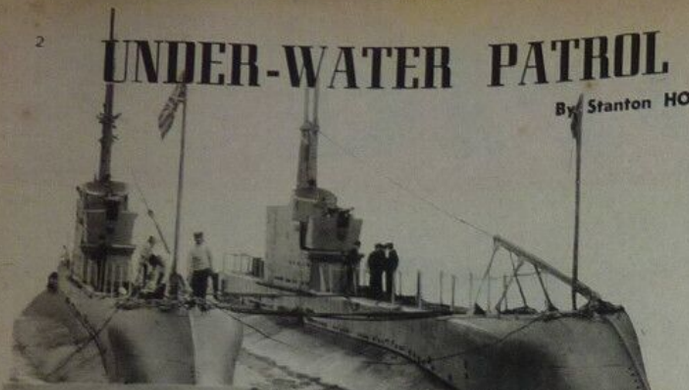


One of J. F. Hanrahan's "blueprints" showing the lungs and alimentary canal with associated structures.

With the aid of sketches from the back, our artist constructed this diagram of a skeleton showing blood vessels, bones, muscles and principal organs.

UNDER-WATER PATROL

By Stanton HOPE



Very confined spaces in a submarine make launching a torpedo an expert job. This picture shows how little room there is in the hull.

SINCE war broke out last September twelve months, oceans of printer's ink have been used to recount the piratical exploits of the German U-boats, but remarkably little has been heard of our own submarines. This, however, is not because our own submarines have been inactive—very far from it. They have been maintaining a silent patrol of dangerous waters, and only now and again is the veil of censorship lifted after some special triumph or tragedy.

Not until the war is over will the full story of the British submarines be told, and the world will learn of the amazing courage and fortitude of the specially trained, hand-picked crews that consist wholly of mechanics and other specialists.

But it is possible to explain some of the normal routine of a submarine, and indicate some of the specialist jobs that go towards the navigation of the craft and her wartime usefulness. In a previous article I dealt with the training of the officers and men, and now let us take a look at the "finished articles" in a new type of British submarine on lone patrol.

Firstly, it should be remembered that submarines vary greatly in size, power and armament, according to the purpose for which they are going to be used. There is the big cruiser type that can keep the seas for long periods and, if necessary, cross the stormy Atlantic. At the other end of the scale, there is the natty "pocket-submarine" specially designed for high speed and to be able to dive in less than a minute, and useful for shorter periods of scouting in the North Sea. Some have a crew of over a hundred officers and ratings, but all have the same big punch—the ability to strike with the navy's deadliest weapon, the torpedo.

There are three vital reasons why a submarine's crew must be picked men, experts at their various jobs and youthful in age. The submarine is the most difficult of all craft to navigate and manœuvre correctly. There is no great margin of error in the delicate task of diving and surfacing, especially under wartime conditions. Then there are peculiar limitations to the submarine's power of fighting and defending herself. And beyond these reasons, it needs a special discipline and training to live and work in the cramped space of a submarine, sometimes in vitiated air that tends to sap mental and physical energy.

Imagine yourself on the cramped conning-tower bridge of a submarine which is steaming in the North Sea in what sailors call moderate weather. Perhaps you may think that "moderate" is an erroneous description, for the boat wallows and rolls, the seas breaking in spume over her grey whale-like hull.

The keen-eyed, youthful captain glances at a chart on which a course has been plotted by the first officer. On the for'ard deck, the trained gunners descend through the gun hatch, for the vessel is going to have a look round in the region of "Hitler's Cabbage Patch"—the minefield near Heligoland—and will be submerged shortly. All these naval gunners, by the way, have become amazingly adept by long practice in racing up from below and manning the gun if the boat is surfacing and going immediately into action.

"Diving stations!"

On the first occasion when I descended through the conning-tower hatch on hearing that order, I had a spine-tingling thrill, as probably you would do yourself. It means that you are going to be clamped down in a steel box of tricks and go a-voyaging in the depths of the sea. Only when you have had long training and practice, does a normal dive become "all part of the job," though a crash-dive away from a pursuing enemy always constitutes a real heart-tearing thrill for every member of the crew.

Bridge gear is dismantled quickly and every one gets inside the boat, including the captain who slams down and fastens the watertight hatch. Then you pass through a second hatch and down another vertical ladder into the control room. The roar and clatter of the Diesel engines dies out; the motors drive the submarine under the waves with a comparatively sweet silence.

Once the depth has been announced, no individual orders have to be given for the dive. Every officer and man is at his station and knows precisely the specialised job he has to do. The captain goes to the eyepiece of one of the periscopes and gently cleans it with tissue paper. Engineers and artificers tend the powerful motors propelling the vessel at nine knots below the sea. Specialist ratings operate the flooding valves and hydroplane controls. Others stand by to control the blowing apparatus, should the craft have to surface again. Men stand alert to signal messages from the control room to other compartments, including the fore end, where the torpedo-men await emergencies by the loaded tubes. One man is ready to move either of the periscopes up and down by mechanical means, according to instructions given by the captain.

Under-sea navigation presents peculiar difficulties which cannot be explained in the compass of a short article. But you can gauge something of these when it is realised that in attacking an enemy successfully, the submarine must be brought to a spot plotted by many mathematical calculations, from where the torpedoes may be fired from under 1,000 yards, which is nearly point-blank range. And most of the time the vessel must proceed "blind," with only an occasional use of the "eye"—the periscope—by the commander. It may be that the periscope can be raised safely only for a few inches above the surface for a couple of seconds at a time, for it may seal the fate of the submarine and all her crew to be discovered before the deadly "fish" are loosed from the torpedo tubes.

Submerged at six fathoms, the boat moves smoothly despite the waves lashing the surface—not even the worst stormy weather is felt down here under the sea.

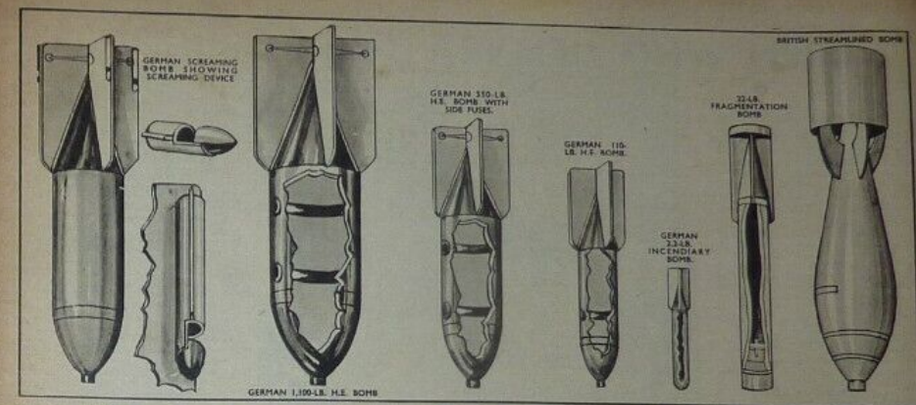
When it is necessary for the boat to run "blind," the specialized work of the ratings who use the Asdic detector becomes of extra importance. For this modern device, whose principle is somewhat similar to the echo-sounding instruments used for ordinary navigation, provides the "ears" of the submarine. A skilled operator can give a surprising amount of information about any ship in the vicinity by means of this Asdic detector, and many a submarine has found her prey and achieved safety herself through the use of this scientific instrument.

Any fellow with an eye for mechanics, would delight in the interior "decorations" of one of our submarines of the latest type. Throughout the boat you will see a thousand-and-one gadgets in gleaming brass and aluminium, added to which, in the control room, are what look like miniature red and green traffic lights, indicators of port and starboard, and a shimmering amethyst colour in spirit levels that show the "trim" of the boat. The engine room is surprisingly neat with what look like polished electric cookers, which are the "fishpans" that enclose the Diesels, pumps and cam shafts.

The patrol beneath the seas in wartime is a nerve-testing service. Officers and men, back from a fortnight's patrol, are glad of the respite when their boat moors in dock or ties up alongside their parent ship, and they are able to have a few days without the stress and strain of hunting or being hunted.

Working conditions when afloat call for mental alertness and physical perfection. Officers and crew are seen at the controls of this "sub."

Orders come from the bridge or control room by means of an ordinary ship's telegraph. Standing-by to operate the starting switches for the motors.



THE BANG BEHIND THE BOMB

The Chinaman who invented gunpowder in conjunction with the aeroplane invention of the Wright Brothers laid the foundations on which modern aerial bombardment is based

Released from a vertical magazine, this sketch shows how a bomb turns over in its fall.

A MAN who is said to have invented aerial bombing (a Spanish general, Manuel Barreiro) died in August. Millions now living wish he had never thought of it, as they wish the Wright Brothers had never succeeded in making that historic first flight thirty-seven years ago, and as they wish that the Chinaman who discovered that saltpetre, sulphur and charcoal mixed together make gunpowder, had blown himself up and taken his recipe with him. It might have been a quieter world today.

The Chinese had been blasting each other into eternity hundreds of years before gunpowder was first manufactured in Europe, its rediscovery, or introduction, is generally blamed on Roger Bacon, an English friar who lived during the thirteenth century. We were using gunpowder in battle, at Crecy, in 1346.

From those early crude cannon we have progressed by leaps and bounds to bombs that, in a split second, can blast away the work of centuries. The science of explosives and detonators and fuses has, we will hope for the good of the world, reached finality. They certainly bungled a lot with their explosives in the early days, a lighted fuse being the beginning and the end of their knowledge of how to make the charge go off.

You may or may not know that you can set light to a heap of gunpowder outdoors and it will quietly burn; it doesn't attempt to explode, because the gases that result from the burning get away into the surrounding air as quickly as they are formed. The big bang comes when you pack a cartridge case with your explosive or stuff it into a bomb, so that when you detonate this the gases have to force their way to freedom—and the bullet (which is the fastest thing man has yet succeeded in making) is sent tearing through space at 3,000 feet per second, or the bomb or shell shatters with terrific force.

A more recent form of gunpowder, known as cordite (gun-cotton mixed with nitro-glycerine, acetone and petroleum jelly) is the explosive that now propels a bullet or shell. An explosive which shatters much more rapidly is used to make the shell or bomb burst.

You could burn that famous and fearsome explosive known as T.N.T. or strike it viciously and it would not explode. You could fill a large shell or bomb with it and hurl it from a height and it wouldn't "go off" when it hit the ground. In fact, it could lie there for years and nothing happen. But give the contents a shock by exploding just a little mercury fulminate in a detonator forming part of the shell or bomb, and that pinch of violent blasting-charge would do the rest—the container bursts by the sudden internal pressure and the almost incredible force of the gas liberated wrecks whatever the pieces of violently disrupted metal happen to miss.

The devilish ingenuity of modern detonators and fuses is partly responsible for the terror which all bombs inspire. A percussion fuse ignites when it strikes anything, that is, on impact. But the explosion can be delayed for any length of time by using a device which prevents the bursting-charge being reached by the burning fuse for a given period.

Another variety of time bomb is filled with picric and sulphuric acids in separate compartments which are divided by a copper partition across the centre of the bomb. The acids attack the partition, each from their own side, and when the copper has been holed and the acids mingle, things happen fiercely. The time taken for this form of bomb to act depends on the thickness of the copper partition.

For use against vessels at sea, aerial torpedoes can be extremely deadly if the aim is good. These elongated bombs are sixteen feet long, weigh 1,500 lb. and cost £1,500 each. Before the aerial torpedo is released, its steering mechanism and speed are set. Then the pilot hurtles down towards his target, the engine of destruction is released and, throwing up a mighty spray as it strikes the water, it dives and continues its journey below the surface, exploding when it hits the warship or other vessel that is to be destroyed.

Before aeroplanes were fitted with bomb-sights, there were far more misses than hits, though heights at which the night raiders now sometimes fly—four to five miles up—render the bomb-sights useless, and indiscriminate bombing is the result.

The difficulty of the defenders detecting these high-flyers will be appreciated when it is realized that the noise of the engines may take as long as twenty-five seconds to reach the ground.

Speed also is against accurate bombing, and when great speed and height are combined it may be necessary for the bomb-aimer to adjust his sights at a distance as great as eight miles from his intended target, the bomb being released whilst the target is perhaps three miles away. It's a lucky shot then if the bomb explodes anywhere near the objective.

Bombs are carried either slung beneath the fuselage or housed inside it. In the latter case, doors automatically slide open and the bombs, electrically released, take their devilish plunge from the machine's interior.

In the earlier days, bombs, which exploded on impact, had to be pitched overboard, and carrying a load of these

As many as 240 of these 2-lb. incendiary bombs may be released at one time.

(sometimes they were actually towed, and cut adrift) was a pretty perilous undertaking for the crew. But even that was an advance on the days when aerial bombs consisted of tins stuffed with shrapnel and explosive, which latter had to be "set off" by the lighting of a fuse.

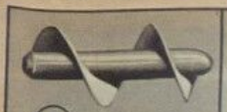
Some Nazi bombs lately have been dropped by parachute, but even if the dropper wished to hit a definite target he would find considerable difficulty in doing so, for the action of the wind on the parachute may be considerable.

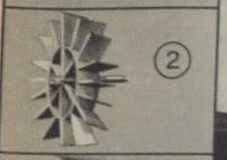
Incendiary bombs with a thermite core, and Molotov breadbaskets, have become familiar enough now. Two newer types are the huge oil-drum bomb, and the calcium carbide bombs which make huge splashes of fire when they explode and, like parachute flares, light up the ground for the benefit of the bombers who follow.

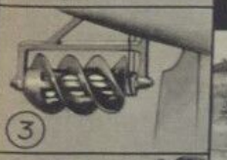
It seems that we shall always have bombs with us, even when wars are ended, for ancient ones continue to come to light in astounding fashion. Making a site for an Anderson shelter in a Ramsgate garden, in September, the diggers unearthed a twenty-five lb. unexploded bomb that had been dropped during the last war.

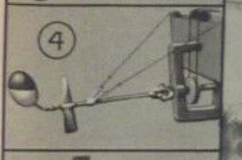
STORY OF MARINE PROPULSION

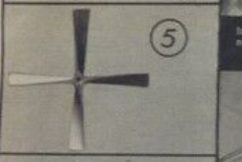
A short pictorial history of the development of the power driven ship

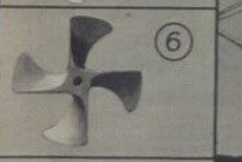


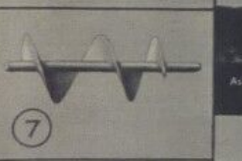


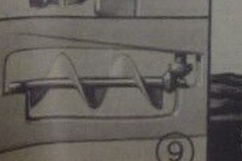


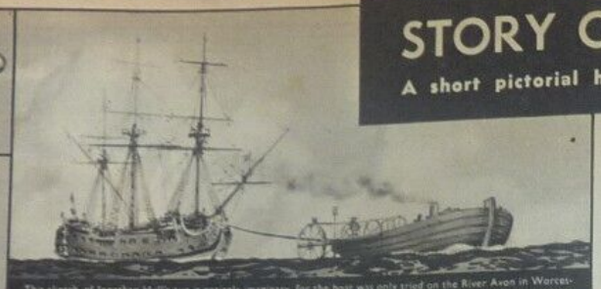






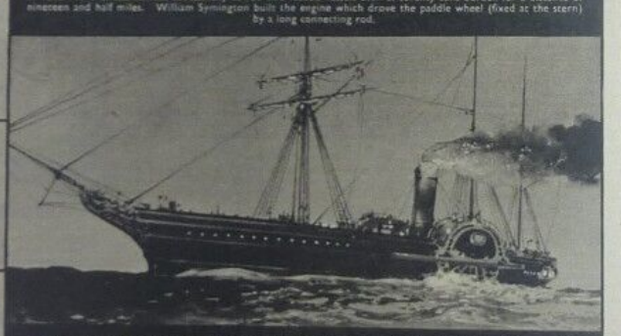






This sketch of Jonathan Hull's tug is entirely imaginary, for the boat was only tried on the River Avon in Worcestershire, with probably small success. James Watt's improvements to the steam engine brought ultimate success very much nearer.

In 1802 the *Charlotte Dundas* successfully towed two loaded vessels each of seventy tons burden for a distance of nineteen and half miles. William Symington built the engine which drove the paddle wheel (fixed at the stern) by a long connecting rod.



As in the early days of the railways many people thought steam vessels unsafe, and when Dickens had crossed the Atlantic on the paddle steamer *Britannia* in 1842, he thought it wiser and safer to return by sailing ship.

MAN'S mastery of the sea was well advanced but had not yet reached its full development in sail when the first important step was taken in the application of power propulsion to ships. In 1736 Jonathan Hulls patented a kind of steam tugboat for the towing of large vessels. Hulls used an engine of the type invented by Newcomen in 1710, which drove a paddle wheel fixed at the stern of a wooden hulled boat. After this early attempt many other inventors turned their attention to the construction of power-driven vessels. In 1802 the *Charlotte Dundas* had successful trials on the Forth and Clyde Canal. Unfortunately, the canal owners, afraid the canal banks would be damaged by the wash of the paddle, made objections and this splendid little vessel was finally broken up in 1861.

After 1800, shipbuilders in several countries began to build steamships and the American *Savannah*, a full-rigged ship with paddles was the first to make the Atlantic crossing.

Brunel also constructed the magnificent *Great Eastern*, which, for many years held the record for size. She had as well as five masts carrying sails, two fifty-six-foot paddle wheels and a screw propeller weighing thirty-six tons.

From the days of the *Great Eastern* to the present day tremendous progress has been made. Many inventions have increased the speed, comfort and design of our modern liners, but the story of these improvements would take too long. After the death of Brunel most of the spade work had been done and modern ocean greyhounds such as the *Normandie*, *Queen Mary*, and *Queen Elizabeth* are really very similar to the old *Great Eastern*.

Fig. 1. In 1776 an American named Bushnell constructed a submarine propelled by a sort of archimedian screw worked by hand. He offered this to the American Government for use against the English, but it never went into action.

Fig. 2. The Brahmah screw of 1785 was never actually used but would have been much more effective than Bushnell's design.

Fig. 3. A triple-threaded screw which was designed by William Lyttleton in 1794, was mounted in a frame that could be attached to the bow, stern or sides of the ship and operated by hand from the deck. A boat fitted with this device attained a speed of only 2 m.p.h.

Fig. 4. In 1800 Edward Shorter designed a most ingenious contraption something like the propeller of a modern outboard motor. A two-bladed propeller on a long shaft with a universal joint was supported by a buoy, as shown.

Fig. 5. Robert Fulton's submarine of 1801 was driven manually by a geared four-bladed screw. A speed of 2.4 m.p.h. was obtained.

Fig. 6. An American design by Colonel Stevens about 1807. This much resembles a modern propeller.

Fig. 7. This design by one, Woodcroft, in 1832, was known as the increasing pitch propeller. It had but small success.

Fig. 8. In 1838 Ericsson's Duplex propellers drove a forty-five-foot steamboat at an average of ten knots. Our unimaginative Admiralty officials were not impressed!

Figs. 9 & 10. In these two sketches we show Smith's screws of 1836 and 1839. The second design was due to the fact that the first, when under test, lost half its thread whereupon the speed of the vessel increased considerably!

Fig. 11. By about 1850 a design known as the "common" screw was almost universally adopted.

Fig. 12. Naval authorities, thinking that the screw would interfere with the progress of a vessel under sail, adopted in the middle of the nineteenth century a two-bladed screw that could be hauled up into the stern of the vessel.

Fig. 13. In 1849 Robert Griffiths patented his adjustable screw. This striking advance in design was not generally adopted until 1860.

Fig. 14. A freak "screw", which completely encircled the hull was designed by Winans for his "cigar" ship. This, unfortunately, gave the vessel a most unpleasant rolling motion.

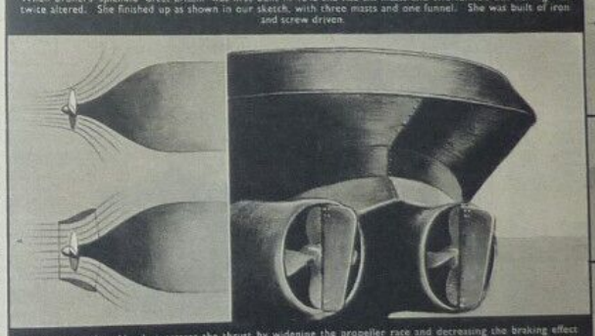
Fig. 15. So that a large screw could be used in shallow water, the "tunnel" screw was designed. The propeller stream gave the vessel something very like jet propulsion.

Figs. 16 & 17. Here are shown the slow-running cargo screw and the fast-running express screw commonly used today.

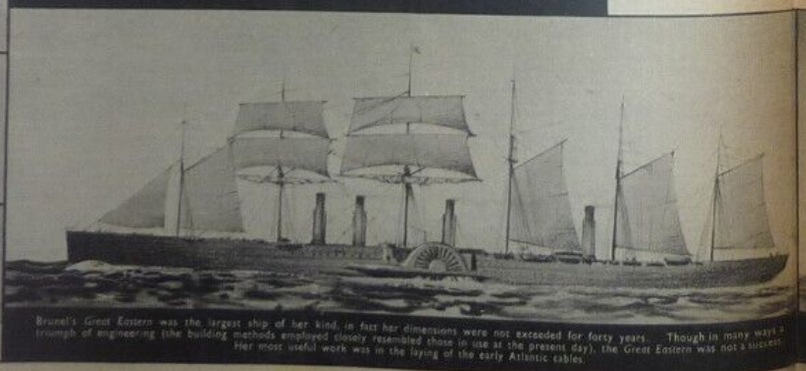
Fig. 18. A striking advance in design is the Voth-Schneider vertical propeller. This has been used successfully on various smallish vessels for about ten years.

In 1845 some marine engineers decided that the screw was more efficient than the paddle and H.M.S. *Rattler*, screw driven, and H.M.S. *Electo*, paddle driven, engaged in a tug of war. To the "paddler's" dismay and surprise, "screws" won easily.

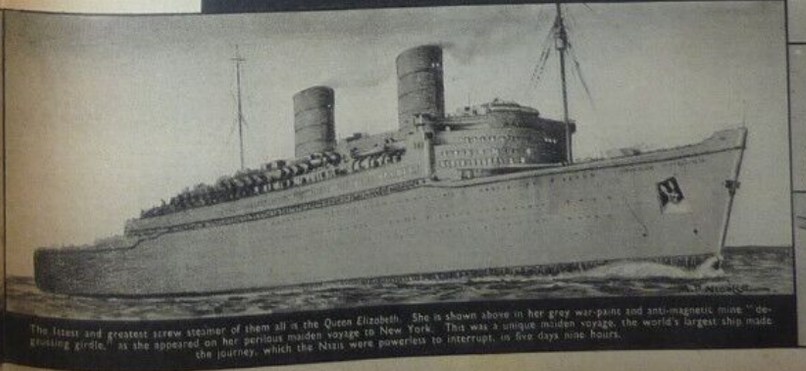
When Brunel's splendid *Great Britain* was first built in 1843 she had six masts and two funnels but her rig was twice altered. She finished up as shown in our sketch, with three masts and one funnel. She was built of iron and screw driven.



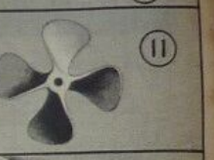
The modern Kort Nozzle increases the thrust by widening the propeller race and decreasing the braking effect of propeller suction. Our sketch on the left amply illustrate this point and that on the right shows the stern of a modern tug fitted with twin Kort Nozzles.

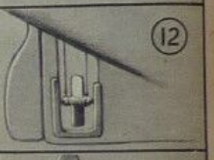


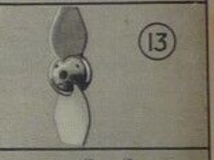
Brunel's *Great Eastern* was the largest ship of her kind, in fact her dimensions were not exceeded for forty years. Though in many ways a triumph of engineering (the building methods employed closely resembled those in use at the present day), the *Great Eastern* was not a success. Her most useful work was in the laying of the early Atlantic cables.

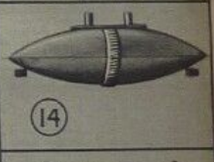


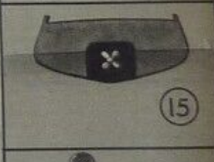
The latest and greatest screw steamer of them all is the *Queen Elizabeth*. She is shown above in her grey war-paint and anti-magnetic mine "degaussing girdle," as she appeared on her perilous maiden voyage to New York. This was a unique maiden voyage, the world's largest ship made the journey, which the Nazis were powerless to interrupt, in five days nine hours.

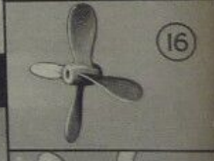


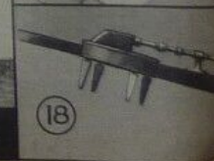












When Big Bertha Shelled Paris

The Nazis threatening London with Big Berthas have apparently failed to learn their lesson from the Kaiser's futile bombardment of Paris in the last war

This is the Big Bertha that, hidden in Corbie Wood, hurled 367 shells seventy-five miles on to the defenceless people of Paris during the war of 1914-18. It was designed by Dr. von Eberhardt, and made for the Kaiser's army by Krupp.

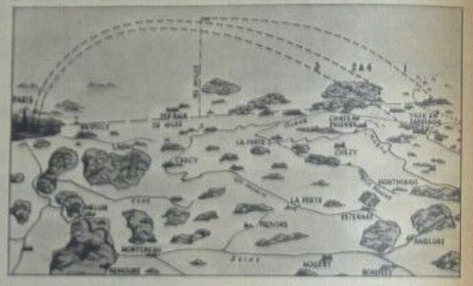
DURING the war of 1914-18, the sudden falling of shells on the houses of Paris caused consternation until the people of the metropolis realised that a long-range gun was responsible. Hidden in Corbie Wood, seventy-five miles from the capital, one of the Kaiser's Big Berthas—he had seven altogether—was attempting to break French morale. He rained 367 shells on Paris, doing £2,000,000 of damage and killing 256 people.

Designed by Dr. von Eberhardt, and made at Krupp's, these guns were able to fire nearly eighty miles. The Germans thought that they had got something good in these long-range guns that fired twice the distance of any other known types.

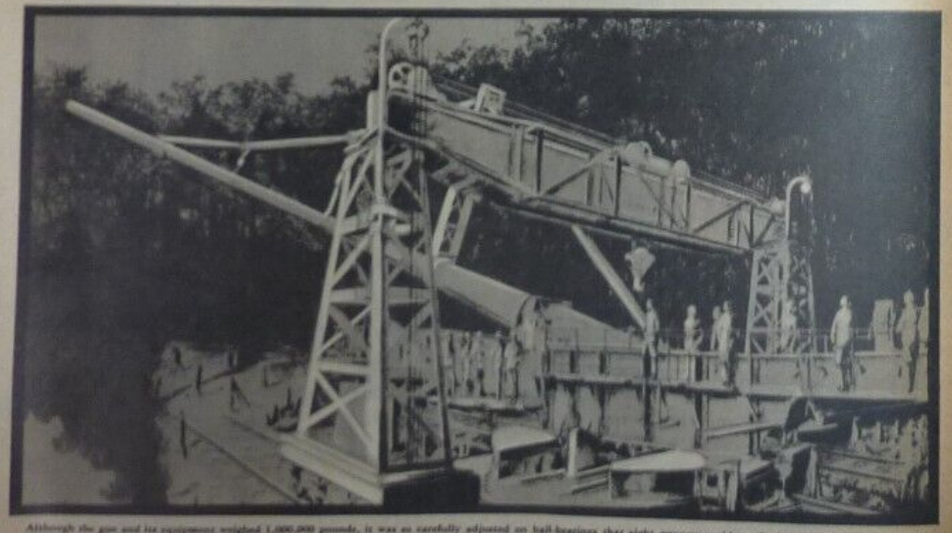
As a novelty to frighten the enemy these guns had their points, but as a serious military weapon they have never been considered highly by experts. Besides the fact that one of the first models exploded, blowing its crew of seventeen to pieces, there are many drawbacks, including difficulty in taking accurate aim at the target, and also smallness of the shell fired. Only 8.26-in. shells were employed, and as elevation was fixed at fifty degrees, range had to be adjusted by varying the charge.

Once again there is the threat of German long-range guns, this time to London. Big Berthas are said to have been mounted on the French coast, and Dover has tasted their inaccurate fire.

We can rest assured that this kind of gun is, at worst, a frightener, and any use that it may have for military work will soon be curbed by the "spotters" of the R.A.F.



Altogether four bombardments were made on the French capital, and this map shows where the guns were located. First time it was seventy-five miles from Paris, the second and fourth sixty-eight miles, and the third fifty-six miles.



Although the gun and its equipment weighed 1,000,000 pounds, it was so carefully adjusted on ball-bearings that eight gunners could manipulate it easily. The shells it fired were little over eight inches in diameter, and these reconstructed drawings show what the Big Berthas looked like before the Germans destroyed them so that they would not fall into Allied hands.

BRITAIN'S "FLUSH-DECKERS"

LED BY H.M.S. *CHURCHILL*, 50 AMERICAN OVER-AGE DESTROYERS HAVE JOINED THE BRITISH AND CANADIAN NAVIES

RELEASE of American "flush-deckers," or as they are more commonly called "obsolete," destroyers to augment the British Navy is one of the bright spots in an otherwise drab story of the recent months of warfare.

Referred to as "obsolete," they may not sound much of an asset, but the name rather belies the usefulness of this new addition to our sea forces. As the First Lord of the Admiralty said in referring to them: "They come at a time when the strain upon our destroyer fleet has been very great, and will be of inestimable value to us not only for escorting convoys, but also for protecting our coasts from the threat of invasion." So whatever the American ships are called there can be little doubt of their value to the senior service at this time.

The fifty vessels that are to be re-christened with names common to American and British towns and villages are part of the remains of the last war. One hundred and sixty-seven of these vessels were built, and because of the number of years that has passed since the keels were laid, American naval experts, not faced with the urgency of a war on their hands, were prepared to condemn them as out of date. Because of the size of the U.S. destroyer fleet, 237 built and some sixty others in the course of construction, America is in the position of having the world's largest number of this type of vessel and can therefore let us have some of the ships that we need for maintaining our shipping lines free from Nazi U-boats.

When America entered the last war, many ships were ordered to swell the Allied fleet. Amongst those that were completed around 1919-20 were the "flush deckers," from which the fifty now added to our navy originally came. Although varying slightly in armament and size they are mostly of about 1190 tons.

On the outbreak of the Great War, some fifty vessels of "V" and "W" classes were being used by the British Navy, and the ships that have now been added to our sea strength are of very similar type to them. Some dozen different builders were responsible for construction, and all the ships were named after distinguished American naval officers.

Although the specification varied in the seven groups in which they were built, most of the vessels were of 1190 tons. Length is about 310 feet, and the ships carry a crew of 122. Original armaments consisted of four 4-inch guns, one anti-aircraft gun and twelve 21-inch torpedo tubes. Speed is thirty-five knots, and 375 tons of oil fuel is carried.

These destroyers were the envy of our men when they served in European waters from 1919-24 because of the luxuries to be found on them. Shower baths and oil-fired galleys, to say nothing of refrigerators, were comforts that were missing on British destroyers. The value of this fleet of fifty is over £21,000,000, to say nothing of the fact that to build new ones would take time and labour that is precious, and can be much better employed producing other war weapons to thwart the Nazis.

Weeks before the transfer was announced there was activity in U.S. naval yards getting these vessels in good running order. Although they were rated as over-age, that only meant that under treaty obligations the American Government was entitled to build new ships. It has been the custom for many years for the engines of all vessels to be overhauled periodically, and many of the ships have been engaged on neutrality patrol during recent months.

Not only have the destroyers been put into full fighting trim but they have also been stocked up with ammunition for their guns and are, therefore, ready for instant action. They may not be new, but fifty destroyers of this type can release our more modern vessels for more aggressive work than convoying, and the lack of refuge with which Berlin and Rome received the announcement and the sneers they used to cover their chagrin show that they at least fear this addition to our overwhelmingly powerful fleet.

Evolved from the early torpedo boats, which, whilst noted for speed and manoeuvrability were difficult to handle, the destroyer has become a most valuable part of any navy. In pre-1914 days many of the duties now carried out by these racing whippets were done by light cruisers. Today their efficiency as ships of war has been well illustrated by their behaviour in the fjords of Norway. Father of British destroyers—and for that matter most foreign ships follows our own for this type of craft—was the *Hawock*, built in 1893.

Experience gained in destroyer design during the last war has formed the basis for those built since. Superimposed guns were adopted, and more recent types have torpedo tubes grouped in fours. A later improvement was the fitting of all-steel bridges. Some other countries have been able to beat us on the speed of some of their destroyers, but the all-round fighting qualities of our ships have not been touched, and the American vessels that now join our navy were built on designs which proved satisfactory in the last war.

Destroyers built recently are larger than the "flush deckers." The average runs into about 1,500 tons, with the new "Tribals" topping 1,850 tons. Fewer torpedo tubes are fitted, and the number of guns is about twice that of these earlier ships. About 1905, Britain built a super destroyer of about 2,000 tons, and as at that time the average was about 800 tons, the size of this ship in comparison probably gave the idea of the flotilla leader of the present time.

Despite the fact that all units of the Royal Navy have undoubtedly been playing an equal part in the maintaining of our prestige and power at sea, the greatest burden seems to have been on our destroyer fleets.

From the dull Channel and North Sea patrol, to escorting minesweepers and convoy duties, their work is humdrum and monotonous, yet frequently there is a dash of colour, some romance and excitement such as was carried out during the Norwegian campaign, particularly in the Battles of Narvik. The *Altmark* affair, which almost forgotten, was a perfect indication of the value of these well-equipped, high-speed old-job boats and revealed the worth not only of the ships but also of the crews that man them.

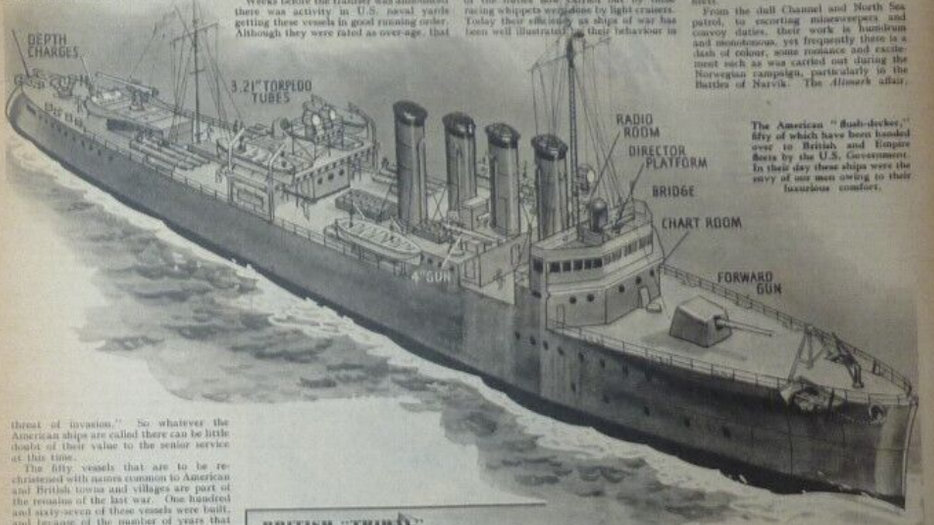
Whether it be on dull patrol or thrilling action, we can never have too many destroyers on the scene.

Latest American destroyers are over 1,800 tons and carry a crew of nearly 200. They carry 5-inch guns, torpedo tubes and are 371 feet in length. Speed of even the newest British or American destroyers is very little above that of the "flush deckers," although some of the Italian ships are claimed to have reached forty-five knots.

The Dutch Navy possesses an outsize in flotilla leaders. This is the 4,000 ton *Tromp*. She carries 5.9-inch, anti-aircraft and also machine guns, as well as torpedo tubes and a reconnoitring seaplane. Aluminium was extensively used to reduce weight so that she could make a speed of at least thirty-two and a half knots, despite her large size.

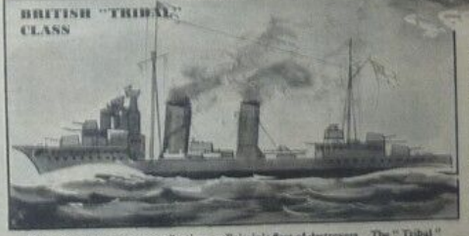
Sweden has recently planned to build a number of 800-ton destroyers. Their job will primarily be to defend the coast, and they will have a speed of about thirty knots. Provision will be made for mine-laying, and three guns and also anti-aircraft guns will be mounted.

Over-age is a deceptive term to use in respect of the fifty "flush deckers" that have now been added to the British Navy. There is no doubt that they will help us to defeat the Nazis and Fascists on the sea.



The American "flush-decker," fifty of which have been handed over to British and Empire fleets by the U.S. Government. In their day these ships were the envy of our men owing to their luxurious comfort.

BRITISH "TRIBAL" CLASS



One of the most recent contributions to Britain's fleet of destroyers. The "Tribal" class weigh approximately 1,850 tons, and torpedo tubes have been sacrificed to permit heavier armament.

NAZI WAR MACHINES

THERE are two types of armoured divisions in the German Army, the light and the heavy. The heavy divisions open a breach in collaboration with dive-bombing aircraft, and the light divisions then follow up to make a break through. In the heavy divisions are the super heavy tanks and flame throwers and heavy medium tanks. In the light divisions which follow are light tanks, armoured cars and motor-cyclists, both types are accompanied by infantry in trucks and lorries. The drawings on these pages show some of the most important types, but of course, there are hosts of other vehicles, such as supply columns, petrol trucks, etc., etc.

The Germans have about twelve tank divisions of five hundred tanks each, the machines being in proportion of six light and four medium to each heavy tank engaged; the combined force comprising a section of eleven machines with a section commander's special tank in charge. He is in close touch by means of a powerful wireless transmitting and receiving set, and conveys his orders to the commanders of the other tanks in his section, all of which are fitted with wireless. It seems strange that the unit of eleven is used so much by the Germans; for instance, they have eleven men on the heavy "dragon," eleven tanks to a section, eleven motor cycles to a unit and so on, but the answer is that in each case there is probably a twelfth member in charge. Hitler will have to cast one of his magic spells and make this lot invisible if he wants to get them over here, past the eagle eyes of the British Navy, and even then, he is assured of a nice "warm" welcome, specially hosted up for him.

How he is going to feed this lot with petrol at the rate of three thousand tons a day, which they require, is another matter.

INFANTRY UNIT TRUCKS, each accommodating six men and drawing a new type of light anti-aircraft gun. These trucks also accompany the mechanized forces.

HEAVY "DRAGON," with new type caterpillar drive, drawing heavy field gun with solid tyred wheels. Eleven men are carried, and it is typical of German mechanized artillery, which follows up a tank attack.

SUPER HEAVY TANK. Weight probably 70 tons. Crew, 12; light and heavy machine guns; 75 m.m. guns, mounced when flame-thrower is not used; range of flame-thrower, 100 yds.; speed, 8 m.p.h.

LIGHT MEDIUM TANK. Weighs 10 tons. Crew, 3; 250 h.p. engine; radius, 100 miles; anti-tank gun and 1 machine gun; speed, 24 m.p.h.

LIGHT TANK. Weight 5 tons. Crew 3; 200 h.p. engine; radius, 150 miles; 2 machine guns; speed, 30 m.p.h.

HEAVY MEDIUM TANK. Weight 18 tons. Crew, 7; 400 h.p. engine; radius, 50 miles; 75 m.m. gun; 1 heavy and 3 light machine guns; speed 20 m.p.h.

HEAVY ARMOURED CAR. Crew, 3; 70 h.p. engine; radius, 200 miles; anti-tank gun and 1 machine gun.

88A.A. 88 C.M. MOBILE ANTI-AIRCRAFT GUN. This is the counterpart of our Vickers 3.7-in. gun. The German gun is lowered by winches mounted either end of a chassis, but its firing stability appears to be inferior to that of the Vickers, and it must have level ground.

A GERMAN MOTOR-CYCLE UNIT, comprising eleven machines, made up as follows: Three solo scouts in front, seven sidecar combinations, and one sidecar combination with heavy machine gun in rear.

L. ASHWELL WOOD

MILITARY LAW

AIMS AT HIGH DISCIPLINE WHILST ENSURING "SQUARE DEAL" FOR EVERY SOLDIER

ONE of the subjects which enters most seriously into the harmonious relationship between soldier and officer is discipline—for the moment considered under the heading of "Military Law."

By failing to give adequate attention to the statement of a delinquent, or by administering an unfair award, it is very easy for an officer to spoil an otherwise excellent soldier, and produce in his stead a "man with a grievance." For this reason, the training of officers includes the close study of military law, and a great deal of instruction in the best way to deal with offenders.

To be really efficient in this relatively incidental part of his duties, an officer has to be a magistrate, a prosecuting counsel, a defending counsel, and a specially appointed impartial observer with the sole function of observing the results of the administration of justice.

Some, who have at one time or another, either themselves experienced what they consider to be rather harsh treatment at the hands of the civil authorities in regard to minor motoring offences, etc., or whose friends have told them of such instances, recognize the importance of giving every man under their control a comfortable feeling that he is always sure of getting a "square deal" at their hands.

N.C.O. MAKES CHARGES

Junior officers are very often called upon to sit in the place of the company commander, and the advice given to them is to ask themselves these questions:—

Is the crime alleged a military crime?
Is the evidence of the person charging the accused honest and fair?
Has the accused a reasonable defence?
Is he capable of presenting his defence?
Have I investigated the evidence of both sides impartially?
Have I proved correctly that the accused is guilty or innocent?
If punishment is to be awarded, what are my exact powers?
Within my powers, what punishment does this crime merit, taking into consideration all the circumstances as regards frequency and gravity? What is the character of the accused?

Every circumstance has to be investigated, proved and analysed, so that the man may feel that he has enjoyed absolutely fair play.

It would be fantastic to imagine that officers have any inclination to inflict punishments on their men; the contrary, indeed is the case in most units, and great latitude is permitted in the matter of passing over minor offences in order that the friendly relationship existing between officers and men in the British Army may be preserved.

A very high standard of discipline, however, has to be maintained and, as a matter of fact, the most efficient unit (and the one most comfortable for all its members) is that which observes the strictest code in this respect. When a man has been a soldier for some time he, in fact, becomes proud of the discipline of his unit, and despises wholeheartedly any other unit which he considers to be slack in this respect.

When a man is charged with an offence he may be placed under open or close arrest. The former permits the man to perform all his usual military duties, but restricts his movements to the confines of the camp or barracks. Close arrest, which is resorted to only when the offence is other than a trivial one, and is for the purpose of maintaining discipline or to ensure the safe custody of the delinquent, means that he is confined to the guard room or some such other place as a substitute.

To ensure that in no circumstances can a soldier be kept in close custody for an indefinite period, however, a wise provision is made which requires a guard commander to obtain within twenty-four hours the details of the charge, and the name and rank of the officer or N.C.O. committing the person into custody. It is the duty of the last mentioned to furnish the details of the offender, but if the guard commander does not receive them within the stipulated twenty-four hours, he has then to make a report usually to the adjutant.

C.O.'s DISCRETION

The commanding officer is responsible for the investigation of the case without delay, and should such delay exceed forty-eight hours he must in turn make a report to his superior officer. In the event of eight days elapsing without the case being disposed of by the commanding officer, etc., and a court martial has not been ordered, a special report is made out and will continue to be made out every eight days until the case is finally brought to a conclusion.

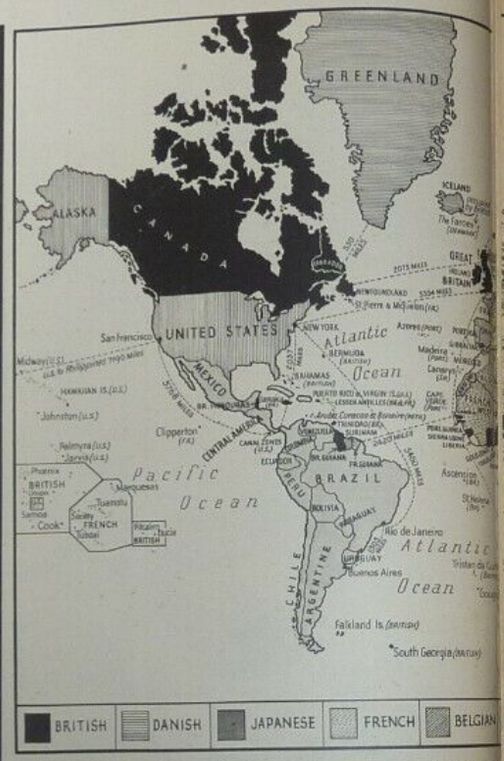
If the case of a man in close custody is likely to be protracted, the C.O. can use his discretion in ordering the delinquent into open arrest, or may even release him (although without prejudice to his re-arrest) until trial or further orders.

Every case against a soldier has to be investigated in his presence, in the first instance by the company commander, although if it is beyond his jurisdiction it will be referred to the C.O. A battalion commander is authorized by the Army Act to delegate power to a company commander, but this generally means the infliction of not more than seven days' C.B., extra guards and pickets, fines for drunkenness, awards for absence without leave, etc., and in the case of the company commander of less than three years' service, his power may be limited to three days' C.B. In any case, punishments given by a company commander are subject to remission by the C.O.

FEW COURTS MARTIAL

A battalion commander has his powers very clearly indicated by the Army Act (Section 46); he may dismiss a charge at his discretion, apply for a court martial, deal with a case summarily, or if the accused is a warrant officer or an officer below the rank of field officer, refer the case to a superior authority. The maximum amount of detention is set out in the same section, the fines for drunkenness, field punishment while on active service, forfeitures of pay, etc., etc., the same section states that, if detention of more than seven days is awarded, no minor punishment can be given in addition.

It is a very comforting fact that, considering all the circumstances, including the strangeness of military discipline to vast numbers of recruits, the number of courts martial is amazingly small. They most certainly are not popular with anybody, and the British officer—better than any one else in the world—realizes that 16 ninety-nine cases out of a hundred, there are so many other effective ways of maintaining discipline where the British soldier is concerned.



WORLD DOMAINS THAT HANG IN THE BALANCE

BEHIND swarms of tanks and bombing planes and myriads of grey-clad troops, Germany is fighting at this moment to prove the truth of Adolf Hitler's statement in *Mein Kampf* that the German race is destined to be "master of the world." It is a battle for supremacy. The stake is nothing less than the established political, cultural, social and economic order in the world.

The Nazi leaders have made no secret of their ambitions. Their professed aim is the forcible recasting of boundaries, the dissolution of empires, the replacement of the old by a new Germanic way of life.

The destruction of British power is the first prerequisite to the achievement of the Nazi aims.

The heart of the existing order in Europe and in a large part of the world is the crowded island kingdom now girding itself for its first invasion of modern times.

Great Britain's position as the world's greatest trading nation rests partly upon an unrivalled merchant marine of 10,600,000 tons, a productive power that sent £532,000,000 of exports into the outer world in 1938, a consuming power that imported almost a billion pounds worth of goods, chiefly raw materials, in the same year.

But it is the empire itself—the empire that is coloured red in schoolbooks—that the present day conquerors want above all. With an area of 18,000,000 square miles—six times the size of the United States—and a population of about 500,000,000, of whom more than three-fifths are in the teeming sub-continent of India, it is the colossus of human organisms.

What applies to the island of Great Britain as the seat of power applies with even greater force to the homeland of France. For France is another relatively small country of 213,000 square miles, with a population of only 42,000,000.

France has few resources of its own to make it a great world power. French culture, French social democracy, French conceptions of liberty which were transplanted across the Atlantic in 1776—all these have been able to influence the world uninterruptedly because of the French conscript army and the French alliance with British sea power.

The French Empire (4,794,000 square miles) is about a quarter as large as the British Empire; about a fifth as populous (106,123,000 inhabitants).

It consists, first of all, of the North African colonies of Algeria, French Morocco and Tunis; the densely forested French Guiana, and her sister-kingdom of Ile-Greenland, and her sister-kingdom of Ile-land—a bleak Arctic empire with less than 150,000 people but lying almost directly athwart the shortest air route across the North Atlantic.

Until now these smaller empires have existed by the grace of the British Navy and the British doctrine of the balance of power.

The threat to the existing order is formidable beyond all precedent.

Behind Germany stand the aggressive totalitartanisms of Italy and Japan, both eager for a redistribution of the riches of the world, both waiting for the moment when they can acquire some of the spoils.

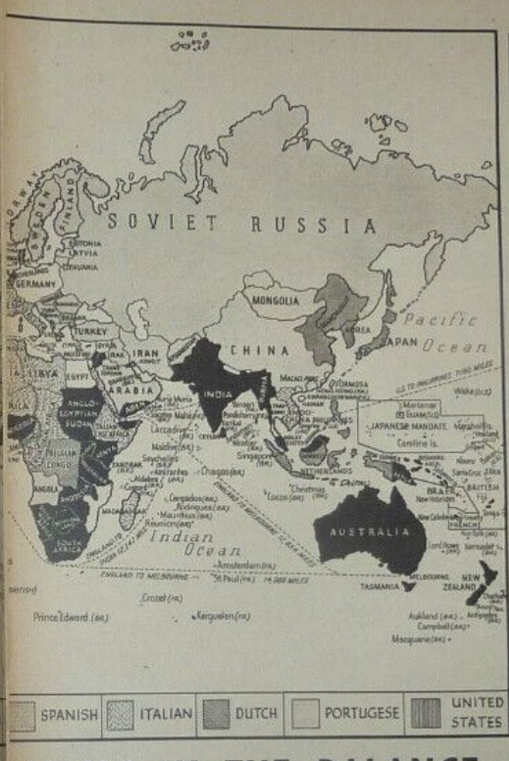
With Germany triumphant, dictating terms to defeated Allies, what would happen to the existing order? One can only guess, but at least the author of *Mein Kampf* and Nazi spokesmen like Rosenberg, Ley and Goebbels have provided blue prints in which the outlines of a German world are visible.

Wilhelmstrasse officials were busy recently with plans for rearranging Europe on Nazi lines. Holland, Belgium, Alsace-Lorraine, they hinted, might become dependencies or fiefs of the Reich, as they were before the Treaty of Westphalia in 1648; and perhaps other neighbours of the Reich, like Denmark and Sweden, would be reduced to the same status of vassalage.

The Balkans, a historic sphere of German economic influence could hardly be allowed their present independence in a German-dominated Europe; they might be made into German or Italian dependencies.

The harshest penalties would be reserved for Britain. With Britain under German control, the title to most of her foreign investments would presumably pass into German hands; the invisible British empire of finance and trade would become an instrument of totalitarian penetration.

(Condensed from the "New York Times")



KILTS TO SEE NO MORE BATTLES

SHOULD Scottish warriors continue to wear the kilt, as their ancestors have done for centuries, or should they adopt the unromantic modern battle dress? The British War Office thinks the time has come for Highland regiments to wear garments which offer them better protection from poison gas, claiming that the kilt takes up too much material, chafes the knees when wet and harbours insects in its folds.

Scots, incensed by a threat to garb which is inextricably woven into the history, romance and song of their homeland, made a protest march to the War Office. At the head of the delegation was the Duke of Montrose, an authority on tartans who has worn the kilt winter and summer for half a century or more.

As he swung proudly along, followed by representatives of various Highland societies, the elderly duke was treading in the ghostly footprints of an ancestor of his who helped to remove a much earlier ban on the kilt.

This was back in the eighteenth century, and the hero of the episode was James, third Duke of Montrose. "Bonnie Prince Charlie"—the Young Pretender to his enemies—had frightened the English by marching as far south as Derby, a brilliant military feat which would have changed the course of history had the prince not been persuaded to turn back then.

The retreat weakened his army so much that it was beaten at Culloden, in 1746, after which Scottish national dress was forbidden altogether, in an attempt to prevent another rebellion.

The Scots had expected to be disarmed, but the ban on their beloved tartans was a deadly blow; the removal of the kilt, the very symbol of martial splendour, reduced them to the level of what they considered miserable southerners.

Many were the runes to which they resorted in order to get round the hated law. Some Scots continued to wear the kilt, merely putting a few stitches down the middle to convert it into rough trousers; some suspended pieces of red, blue or green cloth from waist to knees, which gave the appearance of the kilt without actually using the forbidden tartan; others, mindful that the law did not insist that breeches be worn, contented themselves with merely owning a pair, which they suspended on sticks and carried over their shoulders when ever they left their homes.

But to most Scots the ban was unbearable and no subject for jest, so the Duke of Montrose appealed to the king of England and in 1782 the law was taken off the statute book.

Highland dress has a romantic history and its origin is lost in the past. Authorities differ on the subject of its age, some putting it at only three centuries, some at six or more, while yet others claim that the Celts were famed for their excellent woollen cloth, the brilliance of its colours, and the variety of its designs when they were still roaming the continent of Europe.

As far back as 400 B.C., they say, the different colours of the Celtic dress showed the status of the wearer. Kings wore clothing of seven colours, poets six, chieftains five, officers three, rent-paying farmers two and servants only one.

Later, it is generally believed, tartans of different patterns became necessary to distinguish one clan from another, particularly when more than one clan lived in the same district.

With all members of a clan wearing the same tartan it became a simple matter for a Scot to tell at a glance from what district a stranger came and whether he was friend or foe—a most important consideration in the days of the old tribal feuds. Even clergy received a special tartan and darker ones for hunting were designed for clans whose tartans were conspicuous.

Until comparatively recently the tartan was woven by hand and coloured with vegetable and moss dyes, which gave a softer effect than modern chemicals. There are still some Highlanders who insist on their kilts and plaids being made of hand-woven material, claiming that it "never wears out."

One member of the Macpherson family possesses a hand-woven plaid which is over 200 years old and has been worn on the shoulders of seven generations. The old dyes, too, have great powers of survival; the colours in garments worn by Bonnie Prince Charlie are still clear even today.

Great skill is shown by those who practise the dying art of weaving tartan by hand. There is one man in Scotland who can weave two clan tartans at once, a feat which probably cannot be duplicated by any one else. When making a travelling rug, for instance, he will put the wife's tartan on the back of her husband's. Ask him how he does it and he will reply with dry Scottish humour: "My eye's on the one and my mind's on the other!"

Possibly it was material like this which made the plaid mentioned in a story told by General Stewart of Garth, an early nineteenth century authority on Highlanders and their tartans. In the fifteenth century one of his ancestors invaded the land of the MacIvors of Glenlyon, who, when he had a feud, like banal men, a party of MacIvors and their leader motioned him to advance alone, so that they might confer.

Garth was wearing a plaid which was red on one side and of a dark-coloured tartan on the other. Before he went to meet the enemy chief he told his men to keep their eyes on his plaid. If they was to be peace, he would leave it as it was; if war, he would turn it red side outermost.

At first, the kilt and plaid seem to be a piece of tartan two yards wide and between four and six yards long. But was folded to hang from waist to knee and held in place by a leather belt; the rest was fastened on the left shoulder with a large brooch (or cairngorm) and arranged so that it hung gracefully. The plaid was usually arranged to form a cloak in cold weather, and the whole costume was as practical as it was picturesque.

Being overtaken by night when far from home, unprovisioned the Highlander cut a whit, for his plaid made an excellent blanket. In those days Highlanders would sleep on the heath in any weather.

Today, Highland dress has been simplified. The plaid is separate from the "little kilt" which, in most cases, yards long but not more than thirty inches wide.

Condensed from the "Tweeds Size Weekly" Gazette

ALTERNATIVE MOTOR FUELS IN WARTIME

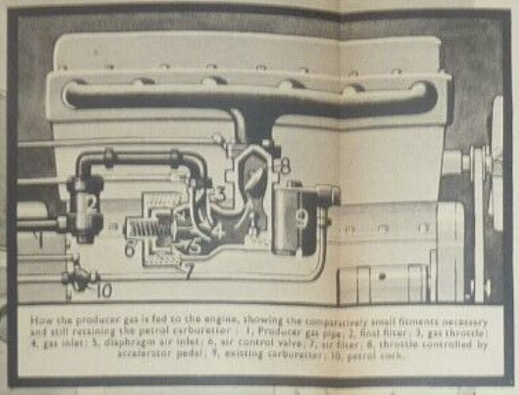
Modern Science in War
World 2

Certain London buses have been running on producer gas for some time and the above drawing shows a typical trailer plant as approved by the Government. The system of working is explained thus:

The engine is started on petrol and draws air through the producer plant causing a draught through the furnace. A torch is applied to the tuyere, the anthracite is ignited and in a few minutes gas is produced. This is cooled, filtered and sucked into the engine. It is here mixed with air and fired by the sparking plugs. Petrol is then turned off.

1, Water-cooled tuyere; 2, ash discharge door; 3, anthracite from hopper falls into grate; 4, off-take gas pipe to coolers; 5, 6, 7, 8, gas passes through these four coolers; 9, filters for cleaning cooled gas; 10, flexible pipe to engine; 11, air intake pipe; 12, fuel charging door; 13, tuyere cooling pipe; 14, hopper filled with anthracite; 15, water-cooling jacket.

Although it is the war that has given the impetus to research work in connexion with producer gas fuel, as an alternative to petrol or crude oil for Diesel engines, the matter had been given a good deal of previous study in the general search for alternatives to the present sources of engine power. Problems of reduced sources of oil have been worrying the scientists for some time past, and efforts have been in hand to overcome future shortages with some form of home-manufactured fuel. The ultimate goal of designers is to produce a gas manufacturing plant that will give as fuel capable of giving as good results as is obtained from petrol engines. Work since the outbreak of war is justifying the hopes held out for producer gas.



How the producer gas is fed to the engine, showing the comparatively small fitments necessary and still retaining the petrol carburettor: 1, Producer gas pipe; 2, final filter; 3, gas throttle; 4, gas inlet; 5, diaphragm air inlet; 6, air control valve; 7, air filter; 8, throttle controlled by accelerator pedal; 9, existing carburettor; 10, petrol cock.

MOTOR cars and vehicles of all types driven by gas and other fuels are likely to play an even greater part in road transport in this war than they did in 1916 when petrol rationing began. Apart from connexions to the carburettor little alteration has to be made to the ordinary engine for adaptation to gas.

There are several methods available of using gas, namely, by gas producing plants installed on the vehicle—low-pressure "balloon" bags using ordinary town gas—high-pressure town gas in cylinders and various methods of using methane obtained from sewage works and coke plants.

England is in the happy position of having immense quantities of gas available and, considering that it is quite easy to derive from it liquefied methane, together with hydrogen, etc., the latter of use to the chemical industry, there seems to be a clear way for building up an industry of great importance to this country.

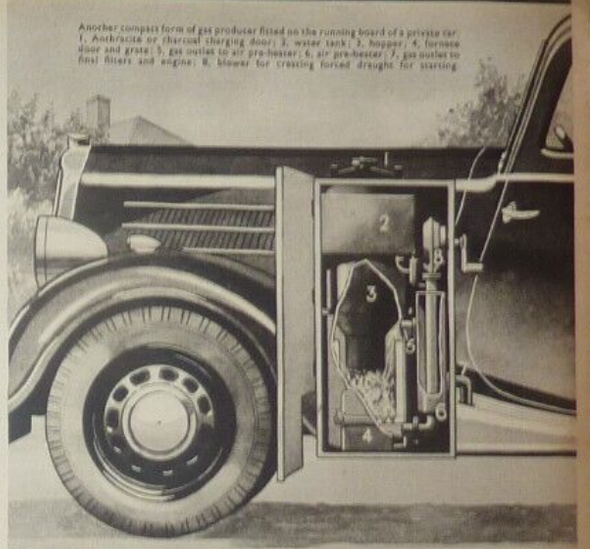
As regards producer gas, results have shown that vehicles are capable of running 120 miles on a single charge of anthracite, and the cost working out at about a halfpenny per mile. The main disadvantage is that the power output is some sixty-four per cent of that with petrol.

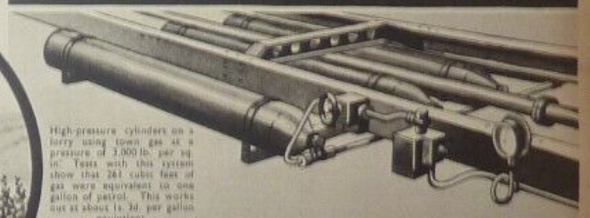
Town gas works at approximately one-third per equivalent gallon.

Fearing a shortage of fuels of all descriptions such as coal, oil and wood, scientists have for many years past been searching for other aspects of the earth's natural resources.

Spearhead of the attack on new forms of power is made by the research concerning the storm, the sun and the sea. Much has already been done to harness these potential power sources, but much more research has still to be carried out if we are to ensure the future of vast industries and modes of transport.

Another compact form of gas producer fitted on the running board of a private car. 1, Anthracite or charcoal charging door; 2, water tank; 3, hopper; 4, furnace door and grate; 5, gas outlet to air pre-heater; 6, air pre-heater; 7, gas outlet to final filters and engine; 8, blower for creating forced draught for starting.





High-pressure cylinders on a lorry using town gas at a pressure of 3,000 lb. per sq. in. Tests with this system show that 261 cubic feet of gas were equivalent to one gallon of petrol. This works out at about 1s. 3d. per gallon equivalent.

Another form of using town gas is low-pressure "balloon" containers. 300 cubic feet of gas will afford a fourteen-mile range for a two-ton lorry. Price about 1s. 4d. per gallon equivalent.

A German system of running on liquefied gases such as methane, butane and propane. Methane can be obtained from the sludge gases of sewage plants. 1, Charging control valve; 2, high-pressure bottles; 3, pipe to engine; 4, regulating valve; 5, heater; 6, high-pressure filter; 7, pressure regulating valve; 8, air valve and filter; 9, throttle valve; 10, carburettor.

ASHWELL WOOD

AMERICAN MILITARY AIRCRAFT—

POWERFUL NEW U.S. PLANES THAT ARE HELPING THE ALLIES TO BEAT THE NAZIS

THE aeroplanes illustrated above are all of American design and manufacture. Many of them are used in the American Air Arm and some have been purchased by the Allied Air Forces and are in daily use in the present conflict with Nazi Germany. Here is a brief description of each type:—

No. 1. Grumman "JF.1." Utility deck-landing amphibian.

No. 2. Vultee "VII.TS." All-metal seaplane for torpedo attack or spotting. Speed 205 m.p.h. Range 1,750 miles. Armament four machine guns, one torpedo.

No. 3. North American "O.47A." Observation plane.

No. 4. Curtis "XSO.3C.1." Triple pontoon, high speed observation aircraft.

No. 5. Ryan "PT.20." Initial trainer monoplane, all-metal construction.

No. 6. Douglas "B.18A." Bomber aircraft.

No. 7. Consolidated "28PB.1Y.2." Four-engined flying boat.

No. 8. Consolidated "31." Twin-engined flying boat.

No. 9. Martin "167." All-metal, twin-engined bomber. Speed 316 m.p.h. This plane is used by the *Armée de l'air*.

No. 10. North American "NA.40B." Twin-engined bomber.

No. 11. Douglas "DB.7." Attack bomber used by both French and British Air Forces. Speed over 300 m.p.h.

No. 12. Consolidated "XB.24." Four-engined bomber.

No. 13. Bell "XP.39" or "Airacobra." Single-seater fighter with shaft drive from centrally-mounted engine. Speed over 400 m.p.h.

No. 14. Vultee "Valiant." Single-seater fighter.

No. 15. Boeing "YB.17." Four-engined bomber. Speed over 250 m.p.h. Armament: five gun positions, one in the nose, one under fuselage, one over fuselage and one on each side.

No. 16. Curtis "P.40." Single-seater fighter.

No. 17. Grumman "G.36." Fleet fighter.

No. 18. Bell "Aircanda." Five-seat, two-motor fighter. Pusher airscrews. Speed 330 m.p.h.

No. 19. Curtis "Hawk 75B." Single-seater fighter which has done good work for the French against the Messerschmitts on the Western Front. Normal armament two machine guns in fuselage. French *Armée de l'air* have four more in the wings.

No. 20. Lockheed "XP.38." Single-seater fighter with twin engines and tail.

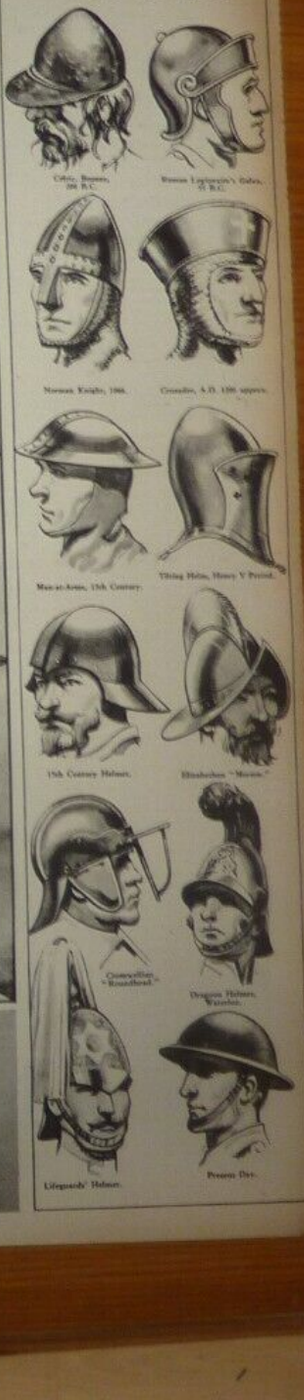
No. 21. Browning machine gun as used on all American military aircraft and on most of those supplied to the Allied Air Forces.

No. 22. Cockpit interior of the Curtis "Hawk" used by the French (No. 19 below). Interesting in showing what the modern fighter pilot has to watch when flying, even in combat. Air-minded readers will recognize most of the components.

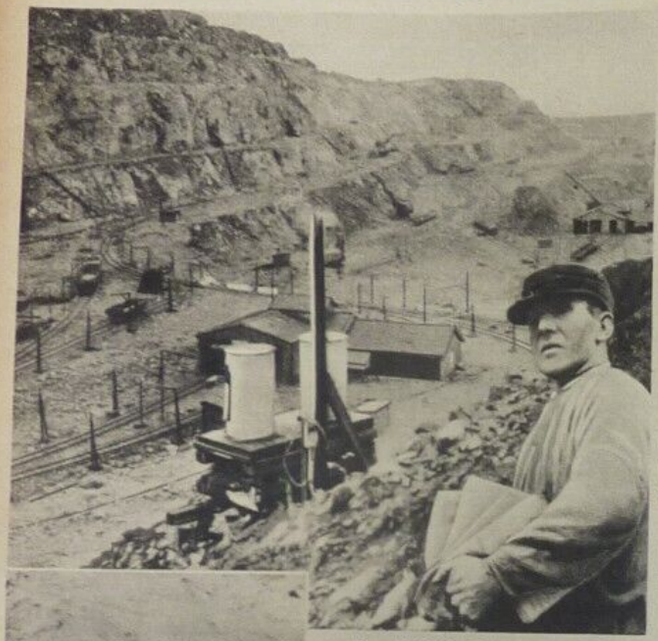
Ryan Ye. 51, known as the Dragonfly army co-operation and observation plane.

HELMETS

Through the Ages



KIRUNA— HITLER WANTS IRON ORE FROM THESE SWEDISH MINES

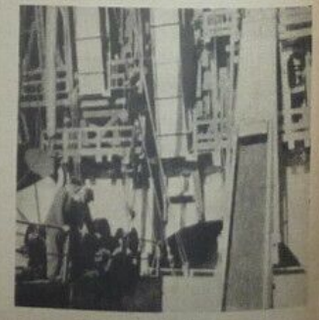


Iron rods used for putting dynamite in the cavities.

(Top) **View of part of the iron ore mountains at Kiruna. The smaller picture shows the drilling machinery used for digging deep cavities in the surface stones.**

(Above) Iron ore arriving by train at Narvik.

(Below) **Through these long chutes ore is loaded on to ships direct from trains.**



By BERNARD HOGBEN

NAZI aggression in Scandinavia is due to the valuable iron ore which comes from the Swedish mines. Without its high-grade quality, Hitler's steel furnaces cannot be fed with essential raw materials, and Germany's war effort will suffer accordingly.

At Kiruna, Swedish Lapland, are the world's greatest open iron ore mines. Experts estimate the ore content of the two mountains of Kirunavaara and Luossavaara at 1,000 million metric tons. Of this vast natural resource about 12 million metric tons are mined annually, and between sixty and seventy per cent is pure iron ore. Sweden, herself, uses twenty-five per cent of the output of this mine; the other seventy-five per cent is exported.

With most other sources of iron ore blocked to the Nazis, it is little wonder that they cast longing eyes on Sweden, and attempted their reckless invasion of Norway when they saw their hopes of carrying supplies of the precious metal through neutral Norway's territorial waters diminishing through the tightening grip of the British Navy. Until the last war valuable deposits of iron ore along the Luxemburg and Belgian frontiers were at Germany's disposal. Now they are out of her control and the Swedish deposits are all-important.

Rated as a bigger prize even than the load obtained through the occupation of Denmark, is the iron which Germany used to obtain through the Norwegian port of Narvik. As proof of its importance are the large number of German naval vessels that lie at the bottom of this Norwegian fjord, sacrificed to the Nazi plan of cornering Sweden's iron ore.

For several years now Hitler has depended for ore supplies on Sweden. The high grade earth contains a higher percentage of phosphorus than other ores, and the German plant has been adjusted to handle this quality. If they could find other sources of supply they would still have to face the problem of adjusting their plant to its use, and therefore regular deliveries from these northern mines has become essential to their fighting strength.

Ownership of such vast natural wealth has put Sweden in an unenviable position. Her ore deposits have had a tremendous influence on her economic position and foreign policy. Alarmed, first by Russian aggression in Finland and later by Nazi threats, she has had to speed up her re-armament plans, and this means that she needs a far greater proportion of the metal for her own use. Recently Nazi requirements have increased, and bullying demands for quick deliveries have been made.

At the same time that the belligerent nations are trying to make it increasingly difficult for each other to obtain her ore, Sweden depends for her prosperity on its export. It is under these difficult conditions, with both sides wanting her valuable minerals, that Sweden is endeavouring to maintain neutrality.

Recent events in Norway have considerably complicated Nazi hopes of winter supplies, but in summer the Gulf of Bothnia route is still open to German ships.

How Sweden's iron ore supplies are finally portioned out amongst the warring nations may have a very big influence on how long the Germans can stand up against the blockade of the British Navy.

WAR HITS WHALES

'Way down in the Antarctic the big mammals are part of the conflict, for their oil means margarine, cooking fats and the household soap

WHALES, sporting and spouting in the cold waters around Antarctica, down at the remotest end of the world, would seem to be happily far away from the lash of war.

In reality their lot is not too fortunate. Whales also feel the burden of war. They must die by thousands, so that soldiers may eat and (occasionally, at least) wash. For whale oil means margarine and cooking fats first of all, and after that, soap.

Even now, battle at sea may unpend over the argosies of the whaleships, on their long way north after a season's hunting in Antarctic waters.

Ten of the ships, representing more than a third of the whaling fleet, are of British registry. Another ten hail from Norway, and it is probable the major part of the oil now sloshing in their tanks is destined also for Britain.

Germany, half-starved for fats and oils of any kind even before hostilities began, would eagerly buy the whole of the Norwegian catch—if only she could.

But Britain has the deeper purse, and no one should find fault with the neutral Norse whalers for selling wherever the best price is offered.

To aggravate the situation, Germany has a fine fleet of six whaleships of her own, plus two more leased from Norway. Last year they went with the rest to Antarctica and brought home their fair share of the slippery spoil. War broke out just before they were due to start south again in September, so now they lie empty at the Hamburg wharves.

Is it any wonder, then, that Nazi eyes look out upon the fat British ships wallowing their way homeward, with a glare of combined hunger and hate?

Not that the Nazis will content themselves with glaring. It may be taken as assured that the German Admiralty is leaving no means untried, to prevent these oil-laden ships from ever reaching their home ports.

Indeed, it is conjectured by some who know the world whaling situation that the real objective of the *Graf Spee* was the British whaling fleet, then just getting settled down to its job of making a season's catch in the Antarctic.

The British victory over the *Spee* may have saved many a scanty fat jar and empty soap dish in Britain.

It is no small prize for which British and Germans match wits and seamanship. Whale oil plays a part in the fat economy of western Europe that Americans seldom stop to think of.

Whale oil in the raw state is such dark, smelly, disagreeable stuff that Americans would never dream of eating anything made out of it, and would even hesitate about using soap known to contain it.

As a matter of fact, modern refining methods are so well able to take the rank odour and dark colour out of the oil that it can be used afterwards in making very acceptable bread-spread and cooking fat.

Also, the oil can be chemically split to get fatty acids for making high-grade soap, with a by-product of glycerine, which is useful in the production of explosives.

In one pre-war year, Britain used 66,000 long tons of whale oil in margarine manufacture, 30,000 tons in lard substitutes, and 49,000 tons in soap. Of all fats used in margarine, 41 per cent came from whale oil. Corresponding percentages were 28 for lard substitutes, 16 for soap.

German official figures lump all uses for whale oil together. Edible fats and soaps combined accounted for 270,000 long tons of whale oil in a typical pre-war year in Germany—54 per cent of all oils and fats used for those purposes. When the war broke out, there was a reserve of whale oil in Germany, but this is believed to be less than a normal year's supply.

Whale oil, as classified in the trade, does not include the product of the sperm whale, aristocrat of cetaceans. This is listed separately as sperm oil.

An important use of sperm oil is in the manufacture of cold creams and other cosmetics. Sperm whales also yield very limited quantities of spermaceti, a fine, thin oil, used in lubricating watches and similar fine mechanisms.

Sperm whales do not figure heavily in the operations of the Antarctic whale fleets; they are wide-ranging beasts and must be taken as and when found.

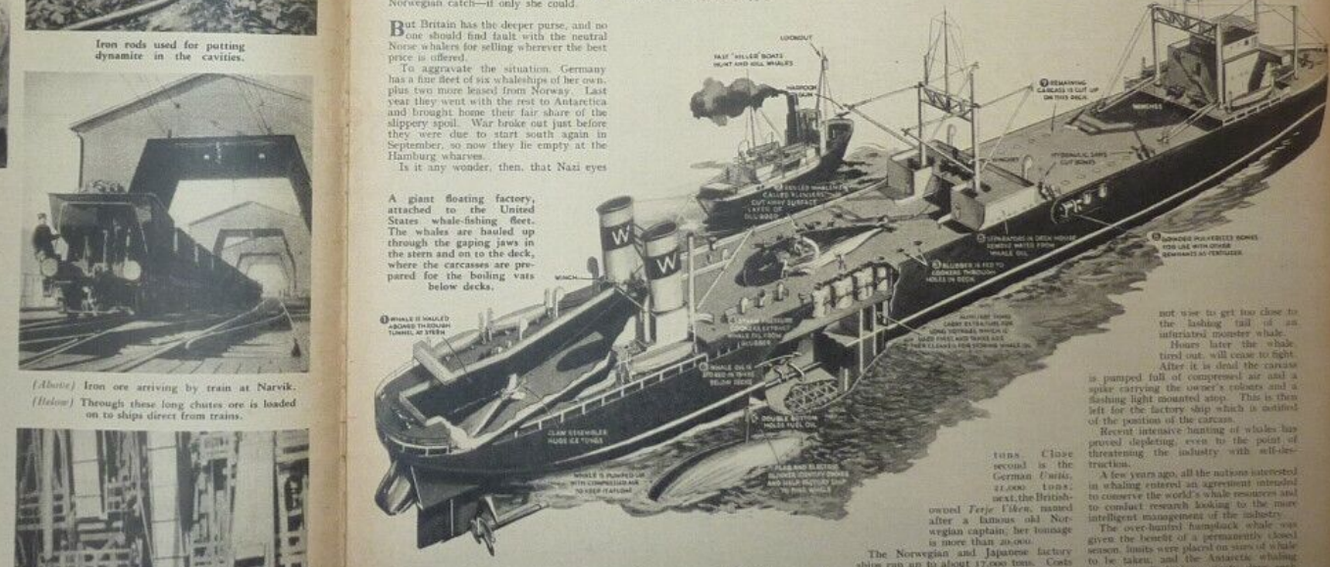
Almost all of the world's whale catching nowadays is done in the Antarctic: whales were hunted out of the Arctic and off the Seven Seas many years ago, except for small numbers.

Practically all whaling is done in highly organized fashion, by fleets of what are known as factory ships, each attended by a number of smaller craft which are known as killer boats, that do the actual harpooning.

The major whaling fleets are constituted as follows: Britain, 10 ships; Norway, 10; Germany, six plus two leased from Norway; Japan, six. No other nation has more than one whaler.

The only American factory ship is the *Ulysses*, owned by the Western Operating Company of New York City. There used to be another, but she was shifted to Panamanian registry some time ago.

A factory ship is usually a pretty big affair, comparing favourably in tonnage with ocean liners and warships. Largest is the Japanese, *Nisshin Maru*, 22,000 gross tons. Close second is the German *Unitas*, 21,000 tons; next, the British-owned *Terje Viken*, named after a famous old Norwegian captain; her tonnage is more than 20,000.



A giant floating factory, attached to the United States whale-fishing fleet. The whales are hauled up through the gaping jaws in the stern and on to the deck, where the carcasses are prepared for the boiling vats below decks.

The Norwegian and Japanese factory ships run up to about 17,000 tons. Costs are as high as £500,000 per ship.

A factory ship is a complicated affair, too. Take as an example the Japanese whaler, *Tonan Maru*, tonnage 19,000 gross, length 619 feet, speed 14.5 knots, crew 329 men plus 19 men on each of her eight killer boats.

Her equipment reads like a riddle to the layman: 12 Kvaerner boilers, 4 Hartman boilers, 4 bone saw machines, 10 oil purifiers.

However, it does mean that the *Tonan Maru* is prepared to haul in the largest whale, take it to pieces in the minimum time, and get all the oil out of it with maximum efficiency.

A factory ship serves as a kind of central headquarters, from which the killer boats put out and to which they return, towing the whales which they have taken, perhaps many hours of cruising away. A killer boat is strongly built, like a tug, but not so stubby and usually a bit faster. She costs about a tenth as much as her parent ship.

A killer's weapon is her harpoon gun, mounted at her bow. The modern harpoon is a terrible projectile. Compared with it, the hand-flung harpoons of the classic days of whaling are mere toys.

Even the blow from a modern harpoon is rarely sufficient to kill the whale; there is life in the monster for many hours after; and as it races through the water, endeavouring to shake the harpoon off, the killer boat is dragged along behind. It is not wise to get too close to the lashing tail of an infuriated monster whale.

Hours later the whale, tired out, will cease to fight.

After it is dead the carcass is pumped full of compressed air and a spike carrying the owner's colours and a flashing light mounted atop. This is then left for the factory ship which is notified of the position of the carcass.

Recent intensive hunting of whales has proved depleting, even to the point of threatening the industry with self-destruction.

A few years ago, all the nations interested in whaling entered an agreement intended to conserve the world's whale resources and to conduct research looking to the more intelligent management of the industry.

The over-hunted humpback whale was given the benefit of a permanently closed season, limits were placed on sizes of whale to be taken, and the Antarctic whaling period was limited to ninety days each year. The 1939-1940 season has now closed.

Even with the new regulations, however, the whales do not seem to be holding their own, as shown by the diminishing returns of the killer boats' efforts.

During the 1934-1935 season the average number of whales taken by each killer boat was 21.1; for the 1938-1939 season the figure had dropped to 13.5 per boat.

In terms of barrels of oil, the returns for 1934-1935 were 181 per day per boat; for 1938-1939 the average had declined to 105 barrels per day per boat.

HOME GUARD TRAINING CHART

BROWNING HEAVY MACHINE GUN

GENERAL DESCRIPTION

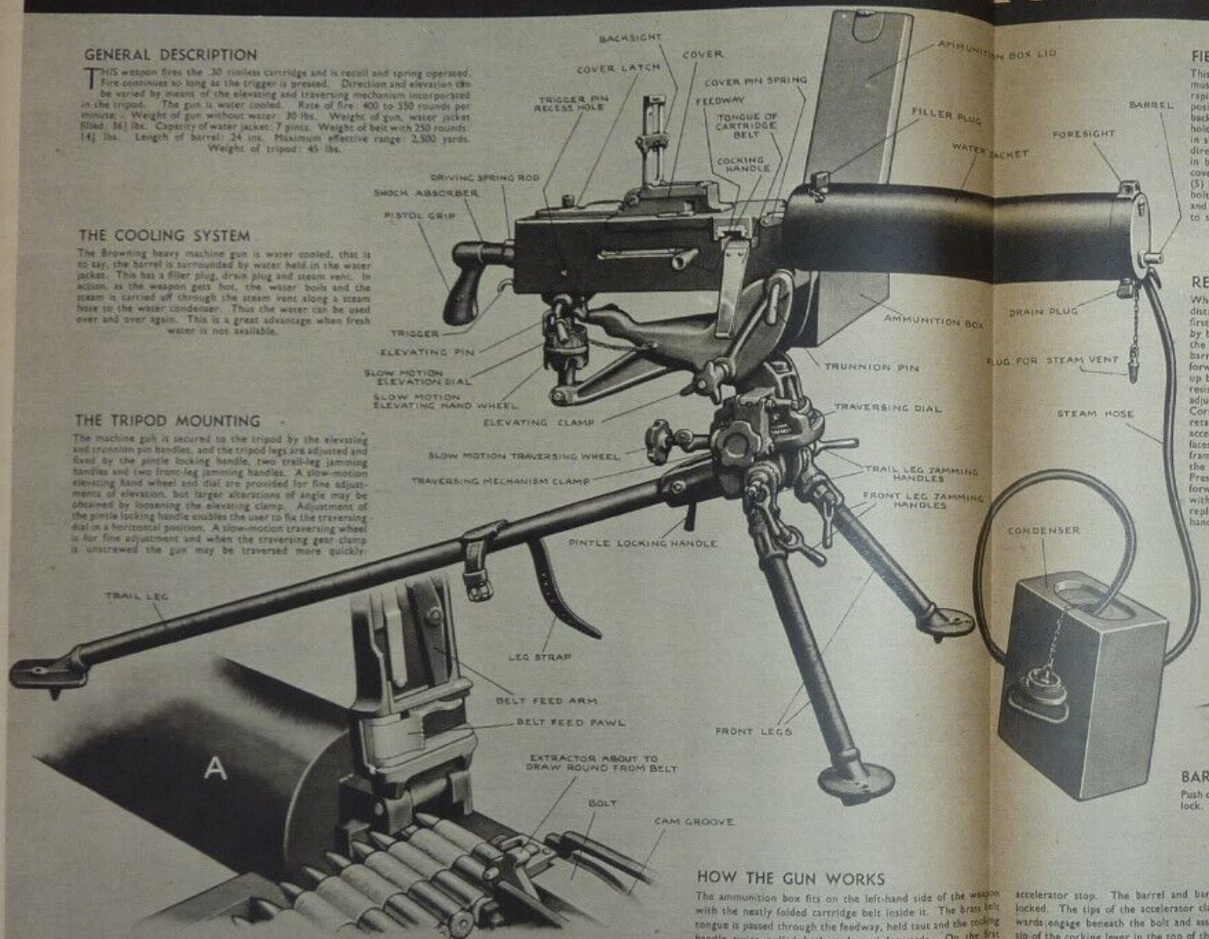
THIS weapon fires the .30 rimless cartridge and is recoil and spring operated. Fire continues so long as the trigger is pressed. Direction and elevation can be varied by means of the elevating and traversing mechanism incorporated in the tripod. The gun is water cooled. Rate of fire: 400 to 550 rounds per minute. Weight of gun without water: 30 lbs. Weight of gun, water jacket filled: 36½ lbs. Capacity of water jacket: 7 pints. Weight of belt with 250 rounds: 14½ lbs. Length of barrel: 24 ins. Maximum effective range: 2,500 yards. Weight of tripod: 45 lbs.

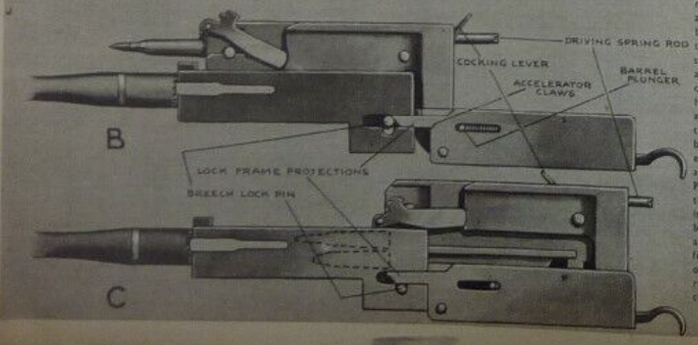
THE COOLING SYSTEM

The Browning heavy machine gun is water cooled, that is to say, the barrel is surrounded by water held in the water jacket. This has a filler plug, drain plug and steam vent. In action, as the weapon gets hot, the water boils and the steam is carried off through the steam vent along a steam hose to the water condenser. Thus the water can be used over and over again. This is a great advantage when fresh water is not available.

THE TRIPOD MOUNTING

The machine gun is secured to the tripod by the elevating and trunnion pin handles, and the tripod legs are adjusted and fixed by the pintle locking handle, two trail-leg jamming handles and two front-leg jamming handles. A slow-motion elevating hand wheel and dial are provided for fine adjustments of elevation, but larger alterations of angle may be obtained by loosening the elevating clamp. Adjustment of the pintle locking handle enables the user to fix the traversing dial in a horizontal position. A slow-motion traversing wheel is for fine adjustment and when the traversing gear clamp is unscrewed the gun may be traversed more quickly.





HOW THE GUN WORKS

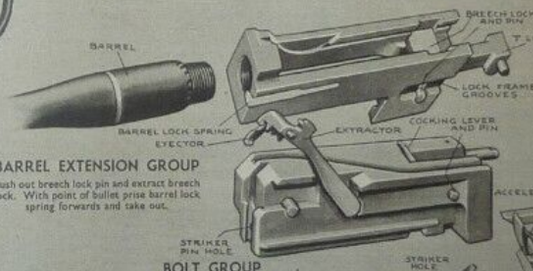
The ammunition box fits on the left-hand side of the weapon with the neatly folded cartridge belt inside it. The brass belt tongue is passed through the feedway, held taut and the cocking handle twice pulled backwards and forwards. On the first movement the first round in the belt is brought into position against the cartridge stops in the feedway. On the second backward movement of the cocking handle the extractor claws the rim of the first round and withdraws it from the belt as shown in sketch A. The bolt travels rearwards and the extractor and round are forced downwards by the extractor cam on the cover. The rim of the round is now held by the T-slot on the head of the bolt. During this backward movement the feed arm actuating stud (engaged in the cam groove in the top of the bolt) is forced to the right. Thus the forward end of the bolt feed arm drives the belt feed pawl to the right. The latter engaging the cartridge belt, brings a second round into position against the cartridge stops. The machine gun is now ready to fire. Pressure on the trigger releases the sear and the striker detonates the cartridge. The force of the explosion drives the bolt (which is locked to the barrel by the breach lock in the barrel extension), barrel and barrel extension to the rear. After a movement of about ¼ in. the breech lock is forced downwards by the lock frame projections. Sketches B and C illustrate this movement of the backward movement. The bolt is now free to continue rearwards and the barrel extension strikes against the accelerator claws, forcing them backwards until they are stopped by the accelerator stop. The barrel and barrel extension are now locked. The tips of the accelerator claws when moving backwards engage beneath the bolt and assist it to the rear. The tip of the cocking lever in the top of the bolt is forced forward during the backward movement, withdraws the striker to the rear and engages the bent with the sear. During the backward movement the driving spring in the bolt is compressed. As mentioned previously the succeeding round is extracted from the belt and as shown in sketch B travels back with the bolt. Sketch C shows the completion of the backward movements where the extractor cam has forced the extractor and round downwards into a position above the expended cartridge case. At the beginning of the forward movement the extractor is forced down still further and the ejector thrusts the expended cartridge case through the ejector opening in the bottom of the receiver or body of the gun. Just before the completion of the forward movement the extractor is forced upwards to engage the rim of the next round. Meanwhile the round on the head of the bolt is fed into the chamber ready to be fired. The forward movement is caused by the reaction of the driving spring which was compressed by the backward movement. As the bolt moves forward it strikes the accelerator claws, moving them forward and unlocking the barrel plunger which, thrust by its spring, drives forward the barrel extension and barrel. The breech lock rides up to lock the bolt to the barrel extension and barrel, and the sear notches engage the trigger bar.

FIELD STRIPPING

This should be understood by every member of the gun crew, who must be prepared to replace worn or damaged parts with the utmost rapidity when in action. Reference to the sketches will indicate the position of every part mentioned in the text. (1) Raise sight, draw back cover latch, and raise cover. (2) Pull back cocking handle and hold firmly in rearmost position with left hand. Insert rim of cartridge in slit of driving spring rod. Push rod well in and turn in clockwise direction until slit is vertical. This locks driving rod and spring in bolt. (3) Push cocking handle forward a few inches. (4) Push cover latch forward and withdraw the pistol grip upwards. (5) Pull back cocking handle and withdraw from bolt. (6) Withdraw bolt and remove extractor. (7) Push in trigger pin with nose of bullet and withdraw lock frame and barrel extension. Push tips of accelerator to separate lock frame from barrel extension. (8) Withdraw barrel extension and unscrew barrel.

REASSEMBLY AFTER STRIPPING

When reassembling the gun "head-space adjustment" (i.e. the distance between the face of the bolt and the base of the barrel), is of first importance. If the space is too great stoppages may be caused by bulged or separated cartridge cases. Too little space may prevent the weapon from firing. To obtain correct head space partly screw barrel into barrel extension. Place bolt (without extractor) in its full forward position in barrel extension and lock in this position by lifting up breech lock. Continue screwing barrel into barrel extension until resistance is felt. Breech lock should now fall of its own weight if adjustment is correct. Mark barrel with correct adjustment for future use. Correct head space obtained, insert barrel and barrel extension, retaining the latter in left hand. With lock frame in right hand place accelerator claws between rear face of barrel extension and forward faces of T-lug extension, with the forward projections of the lock frame in the grooves of the barrel extension. A forward push with the right hand will secure the lock frame to the barrel extension. Press home the complete assembly, push in the trigger pin, and continue forward thrust until trigger pin clicks home. Insert bolt and extractor with cocking lever in forward position. Insert cocking handle and then replace pistol grip. Pull cocking handle to rear, holding with the left hand, and use base of cartridge to turn driving spring rod and release driving spring. Allow bolt to return under control.

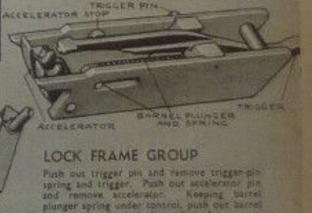


BARREL EXTENSION GROUP

Push out breech lock pin and extract breech lock. With point of bullet prise barrel lock spring forwards and take out.

BOLT GROUP

Remove extractor and with cocking lever in rear position press sear downwards with point of bullet. Push out cocking lever pin and remove cocking lever. With point of bullet push sear spring to left and remove sear downwards. Replace sear spring. This and the sear-spring pin can now be removed upwards. Tilt bolt and striker and spring assembly will slide out. Push out striker spring retaining pin and spring will come out. Turn driving-rod notch and remove driving rod and spring under control.



LOCK FRAME GROUP

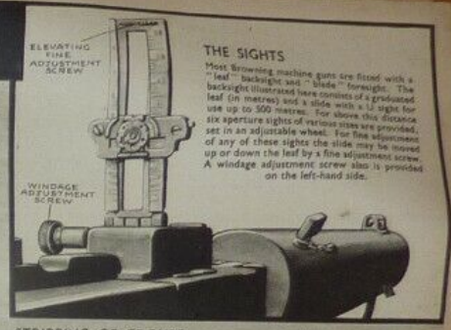
Push out trigger pin and remove trigger-pin spring and trigger. Push out accelerator pin and remove accelerator. Keeping barrel plunger spring under control, push out barrel plunger head pin from slit in frame.

THE GUN CREW

Six men comprise the gun crew. When assembling, No. 1 goes to the tripod and sets it up, No. 2 to the machine gun, and No. 3 to the ammunition box. These men look over their charges and report "All correct," and are then given the order "Assemble gun." When the gun is assembled, No. 1 sits on two ammunition boxes behind the weapon as shown in our sketch, No. 2 takes up a position on the left-hand side, and No. 3 is close by just behind on the right. The remaining three men are replacements in case of casualties. If No. 1 is shot, No. 2 takes his place, No. 3 takes No. 2's position and No. 4 acts as No. 3.

THE SIGHTS

Most Browning machine guns are fitted with a "leaf" backsight and "blade" foresight. The backsight illustrated here consists of a graduated leaf (in metres) and a slide with a U sight for use up to 500 metres. For above this distance six aperture sights of various sizes are provided, set in an adjustable wheel. For fine adjustment of any of these sights the slide may be moved up or down the leaf by a fine adjustment screw. A windage adjustment screw also is provided on the left-hand side.



STRIPPING OF GROUPS

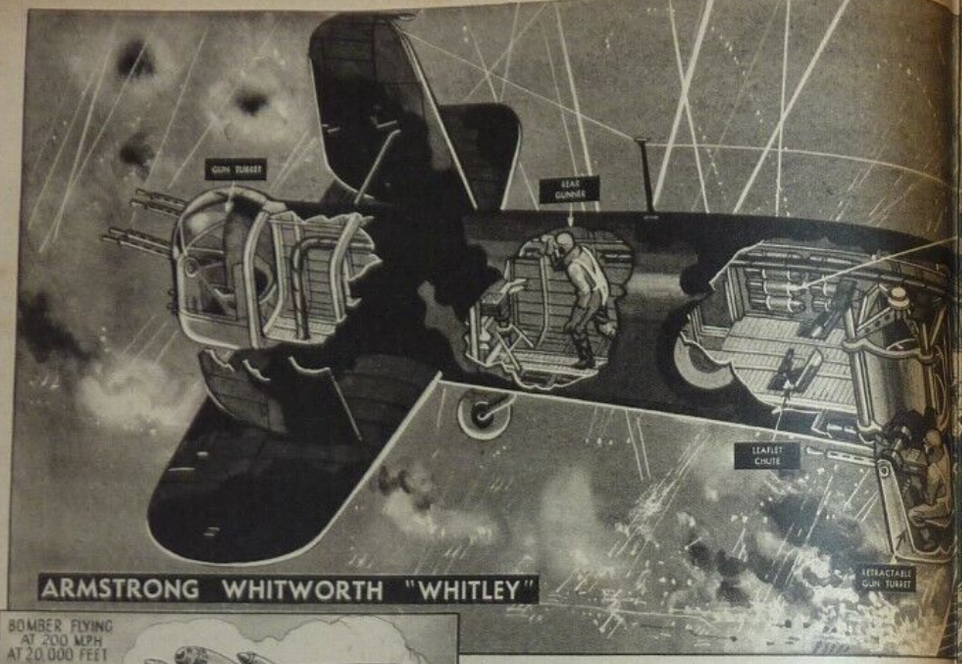
When damaged parts have to be replaced during action a complete knowledge of every detail is essential. We give below sketches of all the groups and a guide to the stripping of each, testing the various parts to which attention must be given.

COVER (Underside)

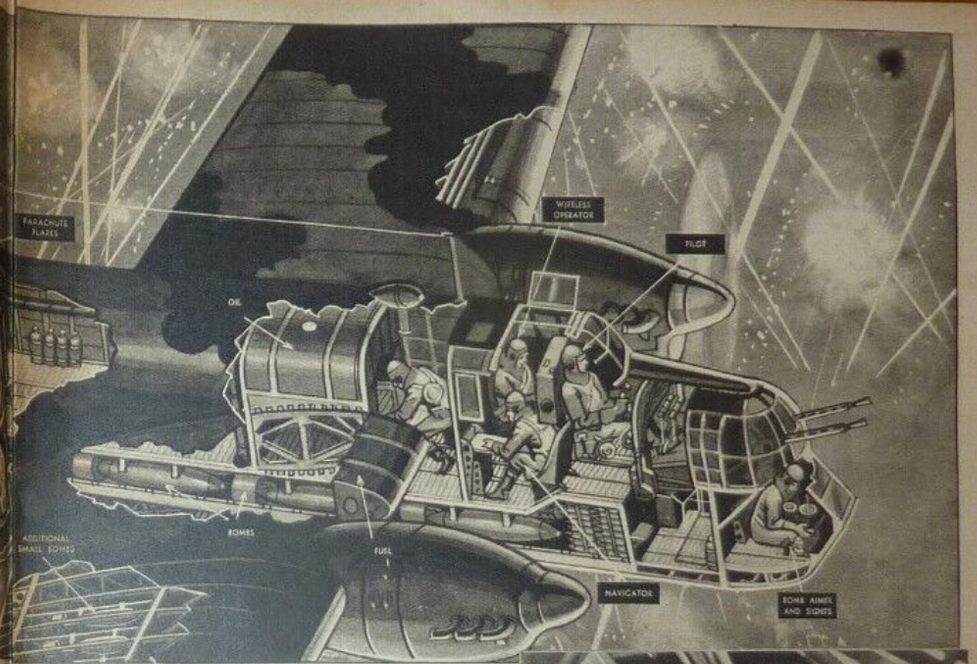
Turn cover-pin spring upwards with point of bullet, withdraw pin and remove cover. Turn feed-lever pivot pin outwards, remove it and take out feed lever and belt-feed slide. Push out feed-pawl pin, remove feed pawl and feed-pawl spring. Remove extractor spring by levering outwards from extractor cam with point of bullet.

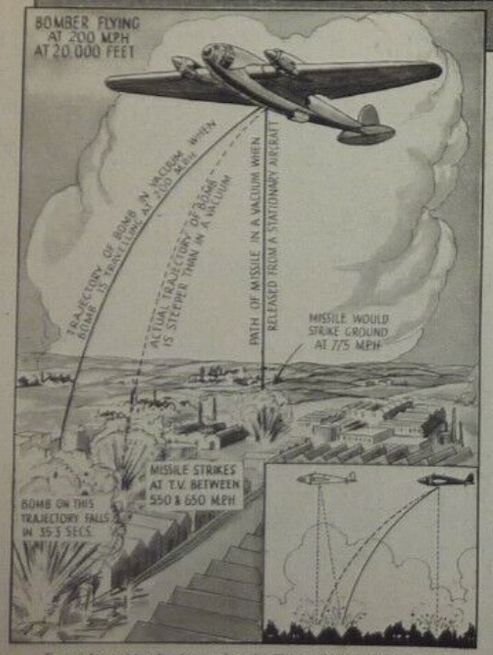
SHOCK ABSORBER GROUP

This seldom needs stripping; its mechanism consisting chiefly of resilient buffer discs held in place by an adjusting screw. If the bolt comes too far in its backward movement the buffer plates absorb the shock.



ARMSTRONG WHITWORTH "WHITLEY"





From left to right the three trajectories illustrated are: a bomb released from a plane travelling at 200 m.p.h. through a vacuum, note the flatness of the trajectory. The dotted line in the centre is the actual trajectory through a normal atmosphere, air pressure makes the path considerably steeper than vacuum travel. The third line represents the path of a bomb released from a stationary aircraft in a vacuum. The missile travels in a vertical line beneath the plane gathering momentum with every second.

HOW THE R.A.F.

THE WORK OF THE INTELLIGENCE DEPARTMENT AND RECONNAISSANCE AIRCRAFT HELPS MAKE THE R.A.F.'s BOMBING RAIDS SUCCESSFUL

by BRYAN S. McCANN

NIGHT after night, in fair weather or foul, R.A.F. bombers climb away from their aerodromes, sweep out across the sea and over the German coastline to attack harbours, munition factories, railway junctions or naval bases according to what is on their instructions. The success of these raids is now common knowledge.

Bremen, Hamburg, Mannheim, Hamm, Essen, Emden, Wilhelmshaven and Kiel are but a few of the names that have figured prominently in Air Ministry communiques telling of devastating raids annihilating those parts of these towns which are of any military significance. The invasion ports, Lorient, Turin, Naples and Milan in Italy, and Northern France, have all tasted the effectiveness of R.A.F. bombing—these boys in the "Whitleys" and "Wellingtons" never seem to miss. If the planes reach their objective, it is certain that the falling missiles will reach their targets. The R.A.F. knows all the ins and outs of the German cities.

How comes this efficiency? How is it that the R.A.F. always seem to hit the particular factory, railway junction or naval base they are sent out to find? We have all seen aerial photographs, yet to most of us they are still "double dutch," a mass of light and shade with nothing particularly clear about them, yet it is principally from these that the R.A.F. are able to hit Krupps armament works, the Hamm goods yard, or Lorient submarine base.

Remember those arduous months at the beginning of the war in which amateur air tacticians sat around in their hundreds bewailing the fact that lives were being lost merely on leaflet raids over enemy territory. "Why not bombs instead of leaflets?" was the frequent cry. Now we are benefiting by those apparently wasted lives and machines.

With every packet of leaflets that went through the chutes aboard the taking "Whitley" aircraft, a camera clicked ceaselessly for the whole of the journey. There and back fly different routes a pictorial record was being made of the ground directly beneath the flying plane. From advanced striking bases in France all last winter on those days in which the weather could be described as "flyable" planes were taking off for the reconnaissance flights that became the object of so much ridicule. It is these flights we have to thank for our outstanding success in bombing operations against enemy military objectives.

Much has been written about what goes on behind the scenes before raiding aircraft take off for enemy territory. The briefing room, the instructions to the crew, the continual reports, the careful description of the objective and so on. For our purposes here, therefore, it is only necessary to emphasise certain of these points.

The Air Ministry Intelligence section is in possession of aerial photographs which form a very good map of Germany, and to this there is continually being added a supply of more up-to-date photographs since as each aircraft returns to its base its camera has recorded new gun emplacements, new dispositions of searchlights and anti-aircraft guns, freshly laid out military encampments and troop movements. All this and more contributes to the R.A.F.'s store of knowledge of their objectives.

When the high-ups at the Air Ministry decide on a raid on a certain military objective, every detail which will assist the pilots in finding their objectives and the navigators in maintaining their courses is attended to. The latest photographs of the objectives are shown to the pilots, studied and explained by intelligence officers who spend their time doing nothing else. All information about the route, amount of "flak" likely to be met, searchlights encountered and so on is placed at the disposal of the raiders. If searchlights remain in one position for any length of time it may be possible to use them as land marks, in a similar manner to celestial navigation.

FINDS ITS TARGETS

When the first plane leaves the aerodrome, therefore, pilot and crew know exactly where they are going, what kind of country they will be flying over, what land marks to watch out for. The navigator has studied his course and knows how to find the objective, the pilot knows the best altitudes at which to fly and what kind of anti-aircraft fire to expect.

The navigator sets his course with the aid of weather reports handed to him before he leaves and little or nothing more is done except to continually check it, until the plane is almost at its destination. Here the navigator, who will also probably be the bomb aimer, takes up his prone position in the front of the aircraft. With hawk-like eyes he watches for a land mark as the plane moves onwards. If there are no clouds about and the moon is up matters are made much easier. With no moon, however, he has to depend on his wits and any badly concealed lights below.

Peering through his glass panel, perhaps he is unable to make up his mind whether he is over the wood outside the city or directly over the city itself. Carefully he watches until many thousands of feet beneath him there flickers a light—an unwary German lighting a cigarette perhaps, or an over-bright torch. At once the observer knows that this is no wood he is flying over.

Through his night glasses he watches the ground closely, a bad car light here determines a main road, a train leaving a station throws up a few sparks, and down the tall chimney of a factory he sees the glow of a furnace. In a flash he knows exactly where he is.

Back at his table he picks up the aerial photograph of the city and taking it to the pilot points out their position in relation to the target. The pilot adjusts his course and while the navigator lies in front keeping an eagle eye open for the target the plane ploughs steadily on its errand of destruction.

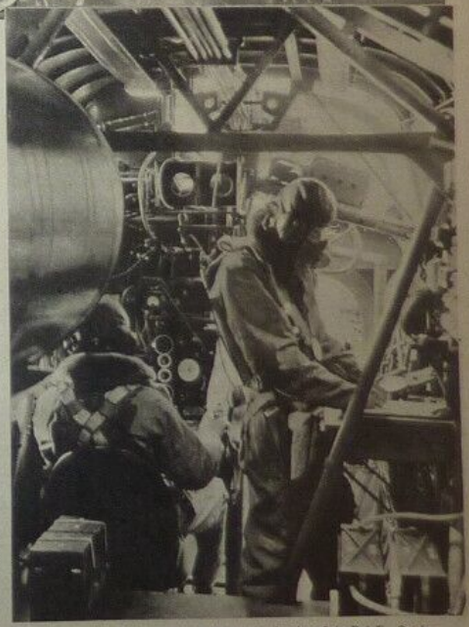
By this method it is not long before the observer knows exactly when he is over the target. Faulty blackouts and other lights reveal a lot to the man in the air who is thoroughly familiar with the area he is flying over.

A couple of flares released from the aircraft as she passes over and the reports of the rear gunner as to what they reveal are the final preparation for the bombing run. The plane turns, heading back towards the target, incendiaries and fire bombs hurtle downwards to start fires to guide other planes following behind and to assist the bomb aimer. High explosives follow.

As the bombs fall one after another and the loud explosions in the middle of the fires tell of direct hits and irreparable damage being done many thousands of feet below, the first aircraft turns and heads for home satisfied of a job well done.

The fires will probably be big ones, and aircraft following at intervals of about seven or eight minutes will be guided to the spot with the aid of the glare which will probably be visible a distance of some sixty miles away. Thus another raid is a success—thanks to the diligence of the intelligence departments and the thoroughness of the reconnaissance flights carried out in the early stages of the campaign against Germany.

Lacking in thoroughness are the German methods. Despite the fact that indiscriminate bombing seems to play a larger part in their tactics than the sorting out of military objectives, when the latter is attempted it seems to be a sad failure.



Two members of the crew of a modern heavy bomber of the R.A.F. On the left the wireless operator sits by his instruments, listening for reports and sending out messages handed to him by the captain of the aircraft. On the right the second pilot and navigator checks his calculations on the chart table. The picture was taken looking forward from amidships.

The Epic of TARANTO

EVERY one is aware of the "glorious episode" in which the Fleet Air Arm dealt the Italian Navy a crippling blow at Taranto, but on these pages we revive the episode by special drawings of Taranto and how the Fleet Air Arm operates. The brilliant attack showed the amazing skill and precision of the crews engaged.

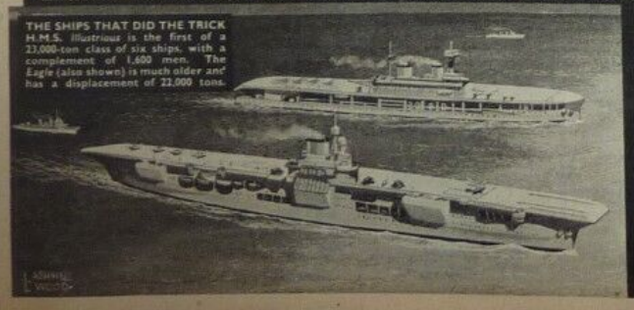
Torpedo-carrying aircraft were first used in the Royal Navy towards the end of the last war, but development was slow until the Fleet Air Arm came under complete control of the Admiralty. Today we have some of the finest torpedo-carrying aircraft in the world and the most powerful fleet of aircraft carriers.

Mussolini must be very sore to think that he did not build any aircraft carriers in his new navy; he probably thought that they could not run away fast enough.

With the after part of the flight deck filled with planes the front machines can take off in a surprisingly small space provided that the ship is going fast into wind.

When landing, a reception signal is given and by means of the hook suspended from underneath the aircraft making contact with the flexible arrester wires, the machine is quickly brought to a standstill.

The "Albacore" is the latest type torpedo-bomber in the Fleet Air Arm. It has a Bristol "Taurus" engine of 1,065 h.p. and carries a crew of three with a torpedo carried externally. The torpedo-release gear is numbered as follows: 1, Torpedo-release lever; 2, quick-release gear; 3, fore clutch; 4, aft clutch; 5, torpedo sling (released); 6, stern catch.



THE SHIPS THAT DID THE TRICK

H.M.S. *Illustrious* is the first of a 23,000-ton class of six ships, with a complement of 1,600 men. The *Eagle* (also shown) is much older and has a displacement of 22,000 tons.

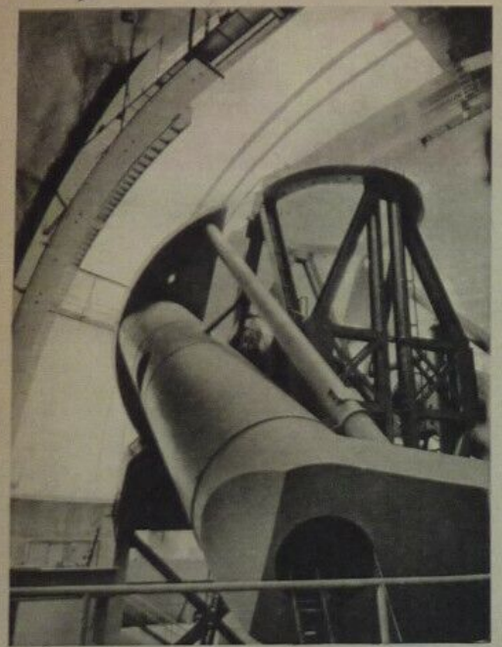
OVER TARANTO

Taranto as it would appear to the pilot of a diving Blackburn "Roc." The Italian warships are seen below in the outer harbour having just received attention from the torpedo-planes on the left which are now turning away for the dive-bombers to inflict the coup-de-grace. Blackburn "Skuas" are also bombing the two cruisers in the inner harbour. These operations were gallantly carried out in spite of the balloon barrage and anti-aircraft fire. It was moonlight and visibility was perfect.

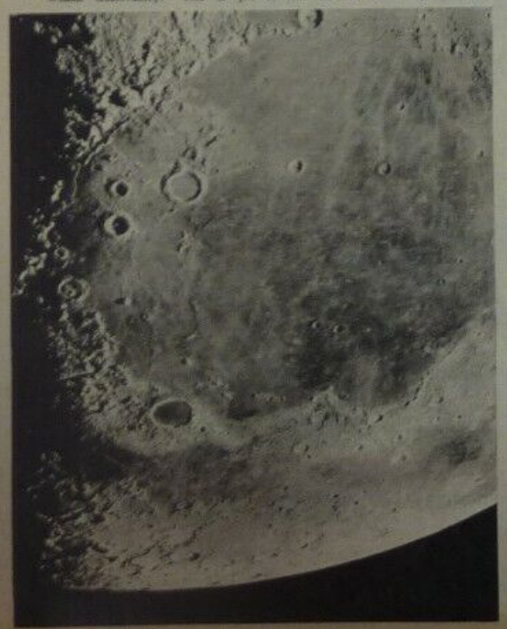
Sequence of dive-bombing operations is as follows: A, Take off into wind; B, circling round until complete squadron is launched; C, squadron formed; D, dive bombing objective; E, circling round for reforming; F, squadron returning; G, landing singly. Existing destroyers with fully manned boats always in attendance.

THE "BAG"

A plan of the harbours showing the result of the attack. A—A1, The Littorio towed to shallow water with bows submerged; B—B1, the Cesare aground, bows submerged; C—C1, the Cavour beached and down by the bows; D, the Trento and the Bolzano heeled over; E, two fleet auxiliaries sunk or damaged.



(Above) This is the delicately balanced machinery used to house the 200-inch mirror. The wonder telescope brings the moon down to apparent distance of twenty-five miles from the earth, and is by far the largest the world has ever yet conceived. *(Below)* Detailed examination of the moon will give scientists wider knowledge of astronomical phenomena. This picture shows the northern portion of the moon and the region from Copernicus to the limb, as seen from the Mount Wilson Observatory. This is yet another of Dr. Hale's giant eyes.



THE GIANT EYE OF PALOMAR

VAN E. CARROL DISCUSSES WHAT THE GIANT £2,000,000 EYE ERECTED ON MOUNT PALOMAR WILL REVEAL TO SCIENTISTS AND HOW THESE DISCOVERIES WILL AFFECT OUR EVERYDAY LIVES

IF only the earth were flat! For then President Roosevelt, when visiting the great 200-inch telescope on Mount Palomar, California, would be able by its help to see King George VI getting into his motor car outside Buckingham Palace, England.

It is only the curvature of our orange-shaped globe that prevents this seeming miracle, for if there should be a balloon barrage on the moon it will soon be dis-covered when the new astronomical eye goes into action.

Over three hundred years ago, a man, whose only crime was that his intelligence was in advance of his time, was brought before the Inquisition, tried, condemned and forced to recant what he knew to be true because he had constructed a tele-scope eight times more strong than any other in existence and by its help had proved many age-old and cherished beliefs to be false. Today, the whole civilized world, happily less prejudiced in its attitude towards scientific research, acclaims the scientist who conceived and the workers who are constructing the world's newest wonder, Palomar's gigantic glass "eye."

It is to the genius of Dr. George Ellery Hale, dreamer, idealist, astro-physicist, that we owe the three giant telescopes at Yerkes, Mount Wilson and Palomar Observatories. From early boyhood up to his death on February 21, 1938, Hale was a stargazer, building bigger and better instru-ments with which to study the sky and its distant constellations; setting himself new worlds to conquer, new goals to reach; an adventurer in the realms of space, striving to master the mysteries of this expanding universe and reach the very confines of the heavens.

Hale died before his last and greatest work was finished; now, two years later, comes word that the 200-inch astronomical masterpiece is almost complete and after final tests should be open to the sky very shortly.

The romantic story has been told many times. The struggle to raise the necessary funds, the heart-breaking delays and accidents are past history, for the gigantic lens is now receiving its finishing touches.

No dusky beauty bound for the harem of an Eastern potentate was conveyed with such care as that given to the 120,000 slab of Pyrex glass when it left the Corning Glass Works in New York State for its journey to the 6,000-ft. Californian mountain. And no attendant slaves ever rendered better service than the enthusiastic workers who for the last three years have been making a scientist's dream come true.

To you and me the chief interest in the telescope lies in what it will find out for us and how it may affect our everyday lives.

FIRST of all we must get out of our minds the idea that if we were lucky enough to visit Palomar we would be able to apply our eyes to the lens and at once see some new world swim into our ken. This "two hundred-inches" is a reflecting instrument and has special photographic devices of extreme sensitivity which replace the human eye, and like other modern telescopes resembles a gigantic camera whose "eye" is a delicate photographic plate.

To take a celestial photograph the image of the object must stay in the same spot during exposure, which may last for several hours or only a few seconds.

Any movement would spoil the picture entirely so that in order to ensure a perfect image the telescope is kept moving to time with the earth by electrical means so that there is no chance of it "getting out of step," the astronomer keeping his eye to another telescope which is set parallel to that used for the photograph, and making, from time to time, any adjustments that may be needed. These photographs, when studied by experts, are the basis of all astronomical discovery today.

When you have made up your mind which part of the sky you would like to examine, the telescope can be swung into position by dialling a special series of code numbers, and sitting in an observation chamber you will be able to see the starry images picked up by the mirror and focused from Cassegrain mirrors slightly below the focusing point of the great mirror. Although you may not realize it, if you ever do get to this "magic" spot you will be able to look at light coming from stars six thousand billion miles away! So that what you do see will not be the stars as they are at that moment, but as they were hundreds of thousands of years ago.

ONE great difficulty in picturing the colossal magnification that the telescope will give is that celestial distances are on so vast a scale compared with those to which we are accustomed on land.

A fairly accurate, but approximate esti-mate would be that the giant "eye" will be 360,000 times as strong as that of an average human being, which implies that starlight from 6,000 billion miles away will be brought within range of astronomical study.

The telescope is housed in a circular structure of 135 feet diameter, the lower part consisting of thirty feet high concrete walls is stationary, but the steel upper portion is made to rotate on a special rail, and it is at the base of this moving dome, some twenty-nine feet above ground level, that the observation floor will be, the telescope pointing through a slot thirty feet wide.

When we start to think what this new instrument will do for us we should remem-ber that astronomy has affected our lives in many ways. When we dial "TIM" on the telephone the accuracy of the "pips" depends upon the observations made from Greenwich Observatory which, incidentally, was built with the primary object of help-ing navigation. And the airmen, upon whose skill we are so much dependent in these days, frequently use the stars to navigate their way across the sky.

The ordinary individual has little know-ledge, and often no interest, in what goes on in the sky, except to dodge into shelter as quickly as possible when bombs begin to fall, but if we only realized it, astronomy is not a local matter run by the parish council but an international affair which actually maintains contact with nations that are at war.

British and German star charts have actually been used by the airmen of these respective countries to show raiding planes the "starry" way towards enemy towns. Our pilots have German astronomical works which have found their way into Britain through neutral sources in the same way that observations made at the Royal Observatory, Greenwich, and printed in German have been used as celestial sign-posts for enemy airmen.

Even with the aid of the Palomar giant, we can never hope to see more than a small part of all the billions of starry universes that make up the heavens, and the question of any details of life as we know it on earth being found on the planets already dis-covered must remain an insolved riddle.

PENETRATING a thousand million light years into space (a light-year being 63,000 times the earth's distance from the sun, that distance being nearly ninety-three million miles) the telescope will bring billions of new stars within reach of the astronomers and it is hoped that science will be able to determine the truth or otherwise of the theory that the stars are moving outwards from us and each other at speeds of 24,000 miles a second!

"If there is life on Mars, shall we be able to see it?" you ask. Well, if there is life, it may be seen, but you should bear in mind the fact that Mars is only close enough to the earth for lengthy study at infrequent intervals so that it may be some considera-able time before we see such headlines as "Looking-in to life on Mars," or "Half-time scores from the Red Planet."

Regarding the moon the new telescope will make this seem only about twenty-five miles away from earth. Just picture to yourself what this means! Those strange mountains and queer craters that have intrigued the world since life began, will now be studied as if they were part of the near landscape. The misty patches that move across its surface may have their secret disclosed, and it will be possible to see whether it is a country of the dead or the living.

Further investigation, too, of other planets will reveal much that at present is hidden. We may find that there is life on Venus, or even on Mercury, and new planets may be shown of whose existence we have as yet no knowledge.

Expert opinion leans to the theory that on Venus conditions might make some form of life possible, and that there is vegetation on Mars is fairly certain. But Mercury, who always turns to the sun the same side of its face, has a surface temperature four times hotter than boiling water, so that it would need some super race of salamanders to even consider existence under such con-ditions.

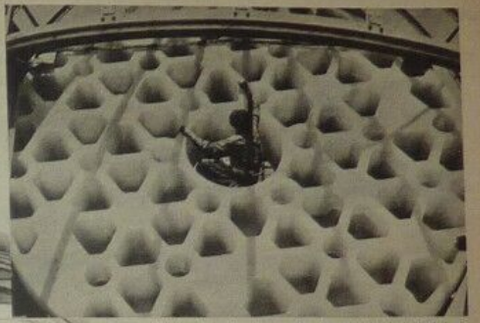
Uranus, Neptune and Saturn are as violently cold as Mercury is hot, for they are covered with blankets of ice, and Jupiter is so freezing that life would have to burrow beneath an ice coat 16,000 miles thick, and a pressure of atmosphere so strong that it even solidifies the gases of helium and hydrogen.

ALTHOUGH the new telescope will bring these heavenly bodies within easier range for detailed study it does not seem prob-able that we shall find life revealed upon them. Perhaps, however, human beings in the not too far distant future will visit the nearest planets by means of rocket travel, and settle these vexed questions, for already men are planning trips to the moon, and interplanetary societies flourish in many countries.

Some astronomers think that the new telescope will solve the riddle of space by putting a limit to it, and by examining the distant nebulæ such a question as this may be settled.

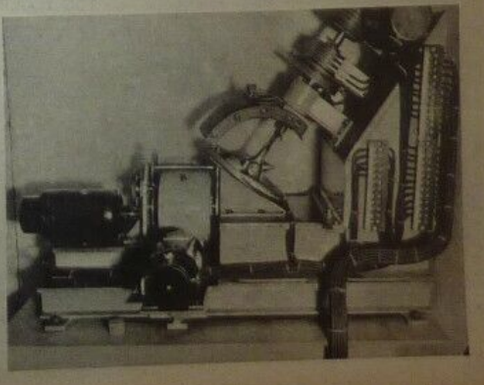
There will indeed be scarcely a limit to the wonders that will be brought into the reach of science when this new investigator gets to work. In the words of Dr. Hale, it should prove to be "the key to those comic laboratories which afford tem-peratures, pressures and masses greatly exceeding those attainable on earth."

Sketch showing the workings of the new observatory on Mount Palomar. The telescope is focused on the heavens through the sliding dome in the roof.



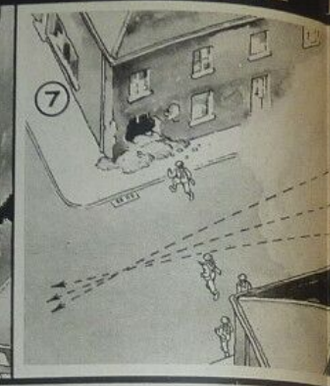
This is the steel web erected to form the hemispherical dome of the special observatory building. This giant eye will see three times farther into space than any previous telescope.

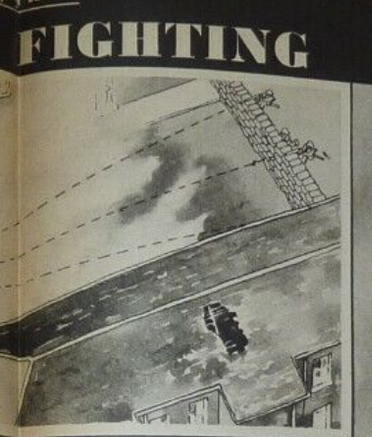
Making the great eye of Palomar has been the greatest precision job the scientists have ever been called upon to tackle. Metal and crystals have had to be shaped to measurements so minute that accuracy has become a science in itself. This picture shows the tiny three-foot robot telescope which is used to control the accurate movement of the dome and giant tele-scope that will explore hitherto remote depths of space in the solar universe.

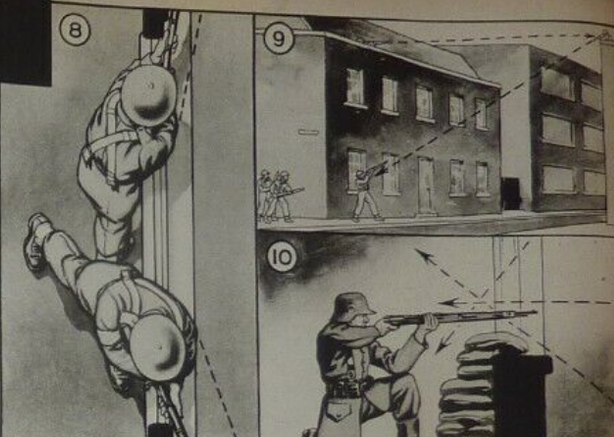


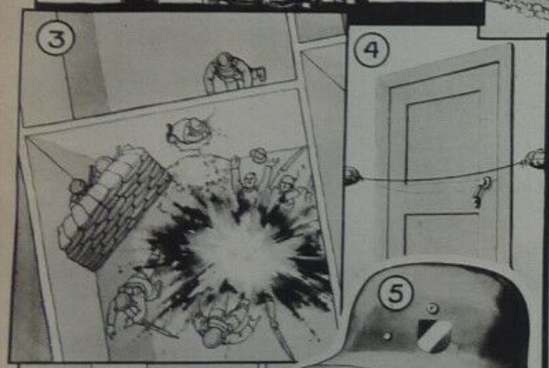
Home Guard Training Chart

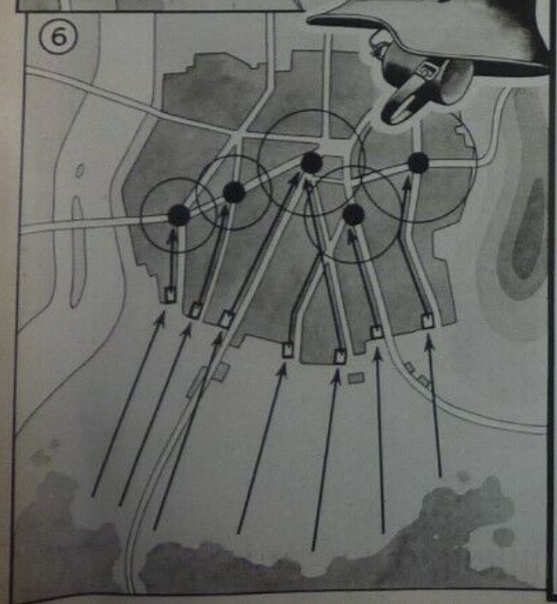
STREET FIGHTING











IF the boasted Nazi invasion ever materializes we can afford to take no chances. There will be street fighting and plenty of it, for Britain is very highly urbanized. Much of the work, particularly in defence, will be carried out by the Home Guard, and all volunteers stationed in or near towns or villages must be well up in the latest developments of this type of warfare.

For this reason much of the matter on these pages has been adapted from lectures given at the Home Guard School by experts trained in the tough battles of the Spanish War. These men have learned all that their German and Italian adversaries could teach them, and have on many occasions beaten them at their own game. The Nazis in particular have developed a new technique in street fighting that is far more efficient than anything that may be learned from previous wars, and the Home Guard must learn every trick in the game.

There are three reasons for the difference in method between street battles and ordinary field operations. These are: (1) Short range; (2) Ample cover, even in ruins; (3) The tank, normally a dominant weapon, is impotent. The reason for the latter statement (which would not be subscribed to by the average "Regular" soldier) is that in recent wars it has been found that the first tank entering the streets can be "knocked out," thus holding up the rest. In any case it is unlikely that any but light tanks will be used because of transport difficulties by sea or air. It is known that the Nazis can carry a light tank slung between the landing wheels of a large aircraft, but to land these weapons a full-sized landing ground must be captured previously.

To show what can be done by irregular troops fighting for their homes and ideals against a well-trained and fully equipped army, this story from Spain is an illustration. The routed Government Army was driven back twenty to thirty miles a day to Madrid. After a further month's fighting in the first five hundred yards of houses, the previously victorious enemy was almost annihilated by what should have been a beaten army.

As shown in Fig. 1, a soldier's equipment for street fighting should be simple. These are essential: shrapnel helmet; haversack; respirator, and ammunition pouches. Such things as the pack or gas sheet are likely to impede progress when climbing through holes and windows. In defence, a water bottle also will not be necessary as there is plenty of fresh water on the spot. An attacking force might of course expect to find the water supply tainted. The correct choice of weapons is very important, and an illustration of the best of these is given in Fig. 11. The rifle is of prime importance, but it should, in the opinion of most Spanish War veterans, always be used without the bayonet.

This opinion is not held by the regular soldier, who says (as a rule) that bayonet and rifle should never be apart in street fighting, except for sniping. On the other hand, it was found in Spain that a fixed bayonet in confined spaces is a danger to one's comrades, and there is little time to fix and unfix it in what is likely to be a mixture of hand-to-hand scrapping and sniping. The twelve-bore shotgun is a very deadly weapon at close quarters, as is the "tommy" gun. A revolver is preferable to an automatic as it is less likely to "jam". A rifle grenade, Mills grenade and smoke bomb or generator also are shown; these are almost indispensable. Each section should be provided with a few building tools such as shovel, pick and crowbar.

One final choice might be a couple of torches, but in this connexion it is advisable when "mopping up" a cellar or dugout to pitch in a grenade *before* switching on the light.

All the foregoing are what might be called "personal" weapons which would be used by both the attacking army and the defenders. Large numbers of light and heavy machine guns must be brought into action on both sides. Artillery also might come into the picture, though not on the large scale used in the "Great War" of 1914-18. This is partly due to the fact that the invader's artillery would be limited (transport difficulties again), and partly also because the Nazis in recent years have evolved the new technique of town capture which is described below.

Fig. 6 is a plan of a small town which has a wide, fast-flowing river to the west, and steep hills on its eastern side. The attack must therefore be made from the south over a flat open plain about half a mile wide between the woods and the outskirts of the town.

In this case the attacker's artillery is used against selected houses on the outer edge of the town. These are selected because of their proximity to a number of streets which lead inwards. When these houses are almost completely destroyed, the attacking infantry advance rapidly in a screen of smoke and behind an artillery barrage. They must keep very close indeed to their own shell bursts, even at the expense of a fair number of casualties. The gunfire on the houses is continued until the last possible moment so that there can be a certainty of no living defender remaining at those points. Once the houses are occupied they are fortified and defended at every point, and the attackers "filter" into the town, fighting as they go, along the chosen streets. A small number of previously arranged concentration points are eventually reached and then the invaders begin to move outwards until the various bodies meet. The southern portion of the town is then slowly but surely mopped up from front and rear and in due course the whole town is taken.

Having said above that the attacking forces "filter" into the town "fighting as they go," we must admit that this is no easy matter and explain exactly how this is done according to the new method. Fig. 2 represents part of a street occupied on both sides by defenders. The attacking force takes (if possible) only one side on the way in. This should prevent the defenders from using their artillery because of the proximity of their own troops.

Having effected an entrance to the first building an upper floor is chosen and a small hole made in the parting wall with a pick. Grenades are lobbed through this to kill the occupants. The hole is then widened and the men crawl through. This process is continued until all the adjoining houses are taken. Important points to remember are that it is always best to occupy the top floors first, a couple of men should be left in each room, each house must be searched downwards and all windows sandbagged or fortified in some way. This type of attack is best of course in a shopping centre where the buildings are in blocks, because a long succession of adjoining rooms means that the attackers are not so much exposed to enfilade fire as when passing constantly from one small house to another.

From the point of view of the defence, one method of meeting this infiltration is shown in Fig. 3. Walls of sandbags are built diagonally against the sides of rooms through which the invaders are expected to pass. Each of these small strong points is manned, the defenders being quite safe from their opponents' grenades. After these have been thrown, a number of unsuspecting enemy are allowed to collect within the room and grenades are lobbed at them over the sandbag wall.

When entering houses that have been abandoned by the enemy, it is wise to keep a smart look-out for possible booby traps.

There are many types of these and no doubt new ones will often be invented by individual soldiers. Sometimes time bombs are hidden in the backs of arm chairs and sofas, and occasionally the ingenious contrivance illustrated in Fig. 4 is resorted to.

A length of string stretched horizontally across a closed door is tied to the pins of two grenades which are fixed to the wall on either side. The man who opens that door is likely to lose interest in soldiering from then on. Another booby trap is shown in Fig. 5. Knowing the British soldier's partiality for souvenirs, the Germans often left a helmet, the lining of which was tied to the pin of a grenade. The latter would be detonated when the helmet was lifted.

In street fighting it is a breath-taking moment when attacking troops must cross a side street from one building to another, when enfilade fire is expected from one or more machine guns. First grenades are thrown to make an opening in the opposite building, and the rush is made under the cover of a smoke generator. As shown in Fig. 7, the first man across is likely to be the lucky one, the others may be caught (if more than one machine gun is used) in a cone of fire. One precaution can be taken. This is to determine by listening, whether the machine guns are fed by belt, drum or clip. It may be possible to make the dash during a period of reloading.

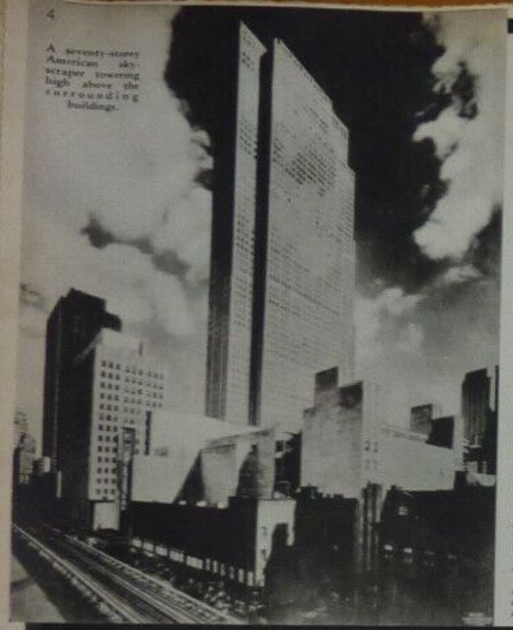
One reason for choosing buildings on the right-hand side of the street is illustrated in Fig. 8. It will be seen that the rifleman defending a captured right-hand window does not expose himself as much as a man firing in the reverse direction. Notice also in Fig. 9, how difficult it is for an attacker firing from street level to hit such a small target as a defender on a roof top. An attacker on the opposite roof has a much better chance; a similar point is shown in Fig. 10, where it is proved that a rifleman defending a window is a difficult target both from above and below. The opponent in an opposite window is much more likely to get his man.

When searching a house never charge up and try to effect a rapid entrance. Creep in quietly to a shell hole or window. If there are no other means of entering, use a grenade, wait ten minutes, then go in quietly and listen. Take off boots, if necessary. Do not worry about a little nervousness, always remember that the other fellow is probably more frightened than you are.

The old trick of putting a helmet on the end of a rifle round an open door is still useful. When the enemy is found, use a Mills bomb. As we mentioned above, it is always best to search a house from the top downwards, but if this is not possible never allow your men to wait in the hall, as they are an easy mark for a bomb dropped over the bannisters.

Here are some final words of advice. Always obtain a plan of the local sewers. Always obtain, and, if any, tube train lines, but drains, and, if any, tube train lines, but be careful of gas mains and sewer gas. When being attacked remember to withhold your fire whenever possible; if you are the attacker, expect it.

This should be the motto of the Home Guard: "Never surrender, never retreat, and it is impossible for Britain to be defeated."



A seventy-storey American skyscraper towering high above the surrounding buildings.

MIRACLE CITIES IN THE CLOUDS

WHEN a world-famous engineer was asked recently for his opinion as to the most important development in building he replied without hesitation: "The introduction of fireproof."

And if we give the subject a little thought we can appreciate the reason for his answer. For fireproof may be the direct means of saving many a large building from total destruction when a conflagration has broken out in some section of it.

Steel which is unprotected cannot be fireproof. For great heat will play havoc with it. Steel girders and other steel framework are naturally fastened firmly to one another, and this is the reason for the damage they may suffer.

Being held fast at both ends, the steel girder naturally has no opportunity for expanding, but when subjected to great heat such a process must take place. Naturally, therefore, the steel tends to bend and buckle, finally breaking down part of the building in the process.

But it is the purpose of fireproof to prevent this happening, and when a building is fireproofed, every single piece of steel used in its construction is protected from direct contact with the heat of the fire. The process is an expensive and lengthy one but results fully justify the money and labour involved.

Each separate length of steel is covered with a layer several inches in thickness of tile or concrete capable of resisting fire for a considerable time. It is in fact, a process of insulation which safeguards the steel from being subjected to any sudden increase in temperature.

Under no circumstances is built-in wood of any sort allowed to be used in the construction of a fireproof building. Metal or some other non-inflammable material must be used for all doors, windows, skirting and floor systems, and picture moulds must be similarly constructed.

In fact, the whole purpose of fireproofing a building is to confine any fire which may start inside one or more of the rooms for some considerable time, thus preventing the blaze from sweeping through the place, fed by inflammable materials.

Therefore, it is a prime necessity for all structural materials to be rendered as impervious as possible to great heat.

Nowadays, buildings are constructed on lines which would often appear revolutionary to the masons of a past day. And perhaps one of the most remarkable facts in the erection of the buildings of today is that the outside wall is very often of no use whatever as a support.

In fact, this curtain, or spandrel, wall serves only to keep out the weather and is nothing more or less than a massive screen. If you will examine photographs of some of the modern skyscrapers that are so prominent a feature of American architecture you will see how this curtain wall is employed.

You will see that often a large number of floors, usually near the top of the building, have no such wall, its place being taken by windows extending from ceiling to floor. In fact, the walls, like those of some fairytale palace, are composed entirely of glass.

In the old days, it would have been impossible to make use of glass in this way for the value of the light provided would be more than counteracted by the draughts which would have whizzed through a myriad of cracks and crevices.

But nowadays, thanks to the efficiency of modern heating systems and the fact that metal windows, no matter how large they may be, can be rendered completely draughtproof, it is possible to dispense with heavier materials altogether.

In fact, so unimportant is the curtain wall to the structural stability of the modern building that it is not unusual to see men at work on the upper storeys laying their bricks for the curtain wall although the floors below them are still without any.

Whether fireproofed structural steel or reinforced concrete is to be used in building construction depends very largely on the nature of the building to be erected. The latter material certainly offers the greater resistance to fire, but it is very much heavier than steel and so this latter is usually used in skyscrapers and other high buildings with a large number of floors, but with long spans and light live loads.

On the other hand, warehouses, factories and other buildings which require the absorption of a considerable amount of vibration and which are notable for length rather than height, are best constructed of reinforced concrete.

Fortunately, our own architects and builders have no earthquake problems to surmount. But it is a very different matter in many parts of the United States, for many of its big cities are in the danger zone and their buildings must be safeguarded as far as it is possible against this form of danger.

But so far has scientific knowledge advanced during recent years that buildings are now being erected capable of standing up to shocks and tremors which would have spelt destruction for their forerunners of thirty or forty years ago.

One of the most successful methods employed in constructing buildings which will stand up to earthquakes is to make all partition walls, exactly as though they were structural walls and not merely flimsy partitions, erected for the sole purpose of dividing up floor space into sections.

Thus, to all intents and purposes, you have not one, but very many buildings, joined together for additional safety and all enclosed in one great outer shell. And in this connexion, it is worth while noting that the building which is most qualified to resist earth tremors is that which has been constructed of reinforced concrete.

When this material is used in making the curtain walls, they are far less likely to fall into the street during an earthquake than are those of tile, stone or brick, which are usually used in the facing of a steel building.

And the damage that can be caused by such objects falling from a great height can add enormously to casualties in some crowded city street.

The modern skyscraper, representing as it does the finest of the builder's and architect's skill is, in itself a work of art. But its towering lines are not achieved by any haphazard building; in fact, very many different experts have to give of their best before one of these amazing towers of Babel rears its slender head high into the clouds.

One of the most responsible tasks is that which falls to the steel engineer. He is responsible for making a detailed layout of all the hundreds of thousands of members required in the construction of the skyscraper, and it is up to him to see that the design conforms to all such essential specifications as economy, safety and such incidentals as freedom from excessive sway.

And the last is a very important point, for skyscrapers must be built with plenty of "give," to resist the gales which strike their upper storeys. But if they sway too freely, the occupants of the higher floors may well suffer all the qualms of seasickness when the building rocks under the buffeting of a high wind.

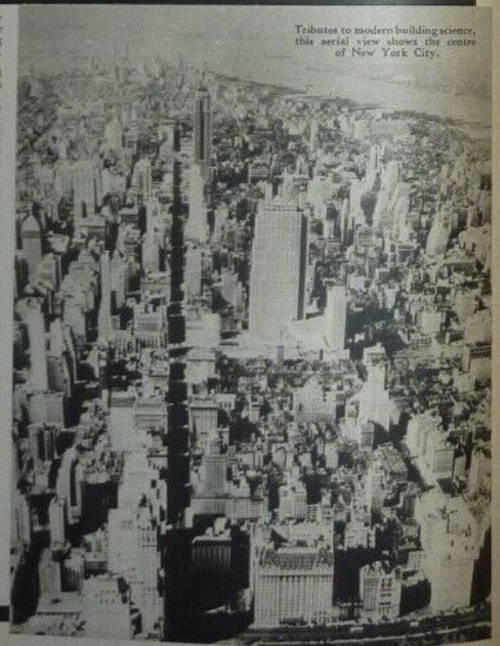
It is the steel engineer, too, who works out the weight and size of all the columns, girders and beams, while it is the duty of the firm which makes the steel to be used to ensure that all material supplied is capable of conforming with the specifications he imposes.

Unexpected difficulties are always cropping up but the Americans have a positive genius for "hustle," and the rate at which their skyscrapers rise is an enduring tribute to the painstaking way in which the constructors surmount every difficulty.

Nothing is allowed to stand in their way and from the architect down to the humblest riveter a personal pride in the undertaking inspires every man engaged.

Yes, modern buildings are something of a miracle in themselves, but the miracle of today is the accepted fact of tomorrow. And in a few short years scientific research may result in buildings which will make the marvels of today seem commonplace by comparison.

For it is one of the great truths of this world that, to the research workers in every field, the best is not good enough.



Tributes to modern building science, this aerial view shows the centre of New York City.

STREAMLINE WARFARE

ANDRE MAGINOT looked out over the fields of Flanders a quarter of a century ago, and from his mud hole he visioned a fortress that would keep hordes of Germans from invading his beloved country.

September, 1939, saw his dream come true and the great armies of France and Germany scowling at each other from the comparatively safe ramparts of the Maginot and Siegfried Lines. The French military mind jibbed at anything which did not include mud and deeply dug holes in the ground although one of their own generals had pointed the way to the new technique of movement and deep penetration. General de Gaulle's theories on mechanization of the army had been freely published in book form, and the Nazis had admitted the value of his suggestions. The country which had produced the technique for a mechanical war continued to put its trust in static defence, and its hated enemy cashed-in on the modern idea.

Horses, with a sprinkling of lorries, and later slow-moving British tanks, were used to transport the soldiers of the last war, and long marching lines of foot-weary infantry advanced a few yards a day, when their side was winning the battle in hand. Development between then and the present left no room for leisurely occupation of enemy territory. The battles of 1940 have been won by swift thrusts. When the time of waiting on the Western Front was finally ended France wilted under the new technique in a few weeks. The days of "foot slogging" infantry were ended; the inevitability of mechanization proved.

Column of motor cycle reconnaissance troops moves off.

The Nazi Panzer Divisions are entirely mechanized divisions of picked troops; their composition is modelled practically exactly on the form suggested to France as early as 1933. Men and machines are divided into six main groups. For reconnaissance work there is a detachment on motor cycles and light cars. Armed with machine guns, these infantry troops were able to capture many villages and small towns before the main detachments appeared on the scene. Real spearhead of the mechanized attack is an assortment of heavy and light tanks; 340 going to a brigade. Then there are five battalions of riflemen. Equipped, for quick movement with motor cycles and fast tenders, they take with them infantry guns and anti-tank devices.

Artillery necessary for blasting a way through any opposition is provided by a regiment of 105-mm. howitzers, mechanically drawn. Specialists of various kinds move with the detachments and they see to such things as camouflage. Finally, a pioneer detachment moves into position for road, bridge and other reconstruction work.

The efficiency of this new form of attack cannot be doubted after its successful launching on the Continent during recent months. With the co-operation of dive bombers, the plan has succeeded in short-circuiting lines of defence that were thought to be impregnable. The bitter pill of the first year of war becomes none the sweeter when we remember that France, not Germany, might have been the sponsor of the new technique.

Significant of the value of mechanization for defence as well as attack are the two actions undertaken by General de Gaulle's division in the last days before the fall of France. At Laon in the middle of May, he fought a four-day battle against the German armoured corps filtering into the "bulge," and won a decisive victory. The fruits of the battle were lost only through lack of support in quick enough time. At Abbeville medium and light French tanks were used in an attempt to stem the advancing hordes. Again the counter-attack of mechanical monsters against their kind was successful, and much material and prisoners were captured.

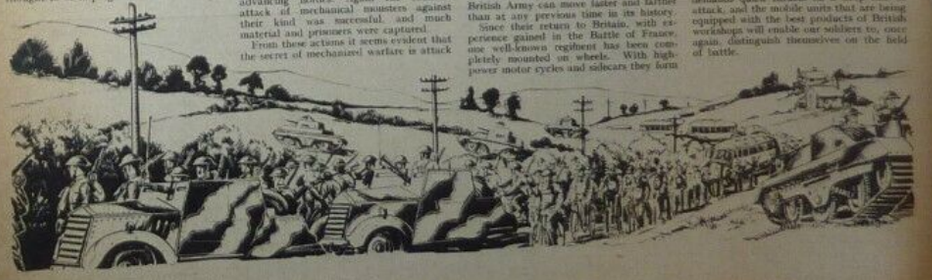
From these actions it seems evident that the secret of mechanized warfare is attack in mass. Small quantities of mechanized forces mixed with units of infantry appear to be ineffective, and the whole question of fighting Hitler's war seems to depend on our ability to mass great numbers of mobile forces in a counter-attack that meets his technique on equal terms.

With the large material losses suffered in the retreat from Dunkirk, the British Government made stupendous efforts to re-equip the army, and the measure of their success has been seen in the defences prepared to meet any Nazi invasion plans. There is every indication that the rearming of our troops has been closely linked with mobility, and that the present British Army can move faster and farther than at any previous time in its history.

Since their return to Britain, with experience gained in the Battle of France, one well-known regiment has been completely mounted on wheels. With high-power motor cycles and sidecars they form a fast mobile reconnaissance unit which is ready to answer any call.

The tendency of the modern army is to get its feet off the ground. For fighting large quantities of tanks, ranging from the 100-ton monsters which are really land battleships, to the easily manoeuvrable little midgets of ten tons. Armoured cars, motor cycles, 18-ton gun carriers, and caterpillared bog-gun hunters all contribute to modern mechanization.

When Britain goes on the offensive it is to be hoped that her battle-dressed troops will be trained as mechanicians and that they will roll to battle on armoured wheels instead of marching to face Nazi *Panzerkorps*. The new method of warfare demands quick thrusts on a deep line of attack, and the mobile units that are being equipped with the best products of British workshops will enable our soldiers to, once again, distinguish themselves on the field of battle.



ESCAPE FROM CAPTURE

A THRILLING TRUE ADVENTURE OF THE GREAT WAR (1914-18)

By Lt.-Gen. Sir Tom BRIDGES, K.C.B., K.C.M.G., D.S.O.

THIS little story takes us back to 1914 when, as you will remember, we were engaged in a sharp difference of opinion with the Central Europeon Powers. In those days it was orthodox early in a campaign for the cavalry of two opposing armies to meet and try conclusions. So, on August 24, shortly after the Battle of Mons, General Allenby with the British Cavalry Division was trailing his coat to try to bring off a fight with a German cavalry corps under General von Marwitz.

The morning had been uneventful, but about noon, when the Second Cavalry Brigade to which I belonged were watering their horses in the little village of Audregnies, we were suddenly told that the Germans were close upon us. My squadron was ordered to go and clear them out. Imagining that it could only be a matter of chasing away a few inquisitive Uhlan patrols, we hurried out of the village at a gallop, drawing swords as we went, for previous contact with the enemy had given us faith in the virtue of cold steel. We made up a dusty lane for an eminence about eight hundred yards to the north where stood a solitary little house. When, however, we arrived on the ridge, instead of meeting German cavalry patrols, we were greeted by concentrated infantry rifle fire, and a few shells from light artillery. One of these burst just in front of my horse and brought us down, and most of the squadron and a machine gun galloped over me and then swung away to the right.

I was knocked quite silly from a blow on the head, and how long I was unconscious I do not know, but when I came to my senses again I found myself inside the cottage with someone pouring water over my head. Besides an old Frenchman and his wife, the house contained about fifteen or twenty wounded British soldiers and some Red Cross orderlies who were collecting the men's arms and stacking them in a corner, apparently getting ready for a surrender. The wooden shutters had been put up on the windows, and bullets were pinging and pattering against them and against the walls. I got a man to help me on to a chair where I could look through the fanlight over the top of the door. From here I saw an amazing sight. The ground stretched away in fine rolling country, nearly all fields of standing corn. But in the corn, marching at open order, came line upon line of German infantry in their pickelhaubes and grey-green uniform, rifles with fixed bayonets slung over their shoulders, just as if the fields of Flanders had been sown with dragon's teeth to bring forth armed men. The nearest German must then have been about two hundred yards from the cottage. Up to that moment I had felt too stiff and sore to get across the room without assistance, but, as they say the best cure for the bedridden is to set fire to the house, so the idea of spending the war in a German prison startled my reflexes into such action that I went through the cottage and out of a back window like the clown in the pantomime.

"A horse! my kingdom for a horse!" Lying in the lane were several dead horses, amongst them my good brown "Umslopagaas"; but in the back garden, amongst the gooseberry bushes, my guardian angel had provided a liver chestnut who was still on his feet, though rather dejected, and bleeding from a wound in the neck. Actually, I think he had been left there by a man who had tried to get me away and failed. I crawled on to his back and we ambled off to the village, sole target, so it seemed, for the whole of a German army corps. But luck held and we reached cover safely. I was the only one of the party who escaped from that house.

At the entrance to the village I passed two of our field guns firing away as steadily as if they had been on the range at Okehampton or Salisbury Plain. They couldn't have been a thousand yards from the enemy, and were doubtless eventually captured, but they must have taken terrible toll of the German infantry first. The village of Audregnies was now deserted, and I rode through it and up the hill on the far side to where there were some empty houses. Here my faithful steed foundered and I had to shoot him, and I sat down by the roadside waiting for something to happen. On a hill about two miles to the west I could see our cavalry division collecting itself. Soon a squadron of the Ninth Lancers came through the village led by Francis Grenfell, very exhilarated and with a bleeding hand wrapped up in a handkerchief. They had just succeeded in saving some guns on the railway embankment, for which Grenfell was awarded the Victoria Cross. This gallant young officer, as well as his twin brother in the same regiment, were both subsequently killed.

I now found that the blow I had received in the face had deprived me of the power of speech, but as Francis told me that my squadron was still behind and would be coming along, I indicated that I would stay where I was and rejoin them. However, when half an hour had passed and still no further troops emerged from the village, I began to realize that the next people to arrive would be the German advance guard, and I was just saying to myself: "What wouldn't I give for a Rolls-Royce!" when, from the opposite direction, a blue and silver sports model glided silently over the hill and pulled up beside me. This was not a vision of my disordered brain but our signal officer, Sadleir-Jackson, who had come back to see if there were any stragglers about. I got in and we ran down into the village again; but finding the Germans already in possession, quickly reversed in a side street and hurried away.

Sadleir-Jackson deposited me at a farm house a few miles back where there was a dressing station. Here I was overhauled and pronounced sound except for a splintered cheek bone and slight concussion. I was given some dope and told to have a good rest, and the two old ladies, who were apparently the owners of the farm, put me to bed on a mattress in the *grenier*, or attic, which I shared with some rats and a stack of bean straw.

Here I slept soundly for some hours, but was awakened in the night by a clatter of horses' hoofs and the sound of voices in the courtyard below. It was a still night with a full moon, and I got up to look out of the window, thinking how beautiful it all was until I saw that the moon was shining down on long steel lances, so close that I could almost have touched them, and on the square-topped helmets of a patrol of German Uhlans. They were interrogating the two old ladies in guttural French, but were experiencing linguistic difficulties and apparently receiving little information of value. As there seemed to be nothing else to do I went back to bed, pulling the bean straw well over my mattress, in case curiosity might lead the Germans to come upstairs. Whether they did or not I could not say, for, in spite of not being sure whether I was now in the enemy's country or not, I went off again into a deep sleep and did not wake until the sun was high.

When I came down in the morning my hostesses, now the sole occupants of the farm, gave me some black coffee and bread, and feeling much revived, and only very sore where some clumsy brute of a horse had stepped on me, I took leave of them and, getting a stout stick, set off on foot for the main road, keeping a sharp lookout and walking carefully under cover of trees along the roadside. When I eventually struck the *chaussée*, I luckily fell in with a party of our own cavalry under my old friend General Hubert Gough, who had me hoisted on to his second horse, "Greatheart," and we followed on in the wake of the retreat.

This little story has a sequel. As a result of the above episode, my name was somehow listed as "wounded and missing," and this news was telegraphed from London to the American Legation at Brussels for the information of my wife. She had left England for Brussels while we were mobilizing at Tidworth with the happy idea of getting the beds aired for us against the time when we should arrive there, and I had seen her off at Victoria Station in a train full of rather depressed German waiters and hairdressers going back to fight for the Fatherland. In Brussels she joined the Allied Hospital where, being a good cook, she worked in the kitchen. When she heard that I had been gazetted "missing," she persuaded one of the hospital stretcher bearers, a Turk, to accompany her to Mons in an ambulance flying the Turkish flag. They carried some much-needed anæsthetics for the hospital there, and she had the laudable intention of finding me dead or alive.

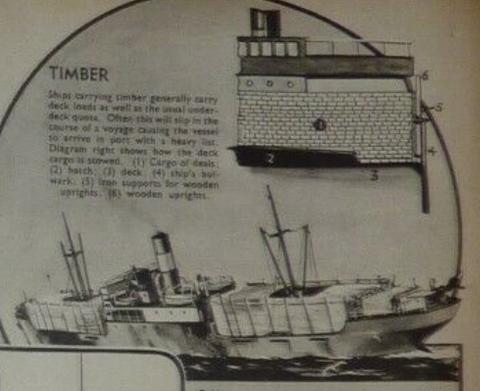
They drove down the main road from Brussels to Mons, through the whole of the German Army, hurrying ceaselessly forward, and found the sight of such masses of troops rather terrifying. They spent the day at Mons searching for me, but naturally drew a blank.

On her return to Brussels that night my wife received a private warning not to go near the hospital as the Germans had taken it over. She had now indeed become a suspect, and was liable to internment at any moment. Disliking the idea of captivity as much as I did, she determined to return to England. This, however, was not so easy. She could not take the train without a German pass and all motor cars had been commandeered. However, after lying concealed in the town for a few days, she left the city in a *fiacre* for the suburbs and eventually purchased a horse and cart and induced her Turkish friend to drive her to Ostend where she managed to escape on the last refugee boat to leave that port.

They say that there were angels at Mons and that people even saw them in various guises; some as knights in armour forming a rearguard, some as English archers guarding the flank, and some as just ordinary everyday angels with wings. Personally, though I saw none, I feel that there was at least one angel present and on duty, who furnished me with means of escape from certain capture on two occasions in one day, besides providing for the safety of my wife.

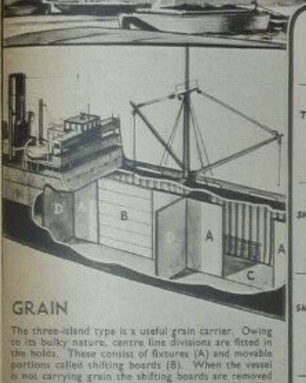
BRINGING HOME BRITAIN'S CARGOES

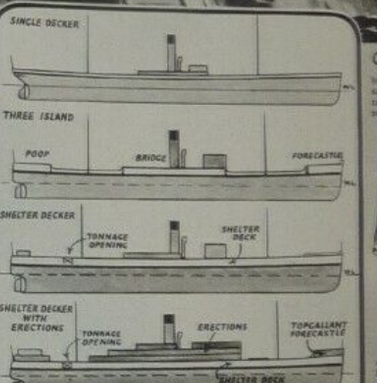
CARGOES of every sort and kind continue to arrive in this country despite the enemy's efforts. The fact that they do is due solely to the indomitable courage of the British Merchant Service. Many of these cargoes are carried under special conditions and in specially constructed vessels. Some of these are shown below together with diagrams (centre) showing how the various types have been evolved. Most ships look alike to the layman, but diagrams on this page will help you to classify a vessel and place her in her particular trade category.



TIMBER

Ships carrying timber generally carry deck loads as well as the usual under-deck quota. Often this will ship in the course of a voyage causing the vessel to arrive in port with a heavy list. Diagram right shows how the deck cargo is stowed. (1) Cargo-of-deals; (2) hatch; (3) deck; (4) ship's bulwark; (5) iron supports for wooden uprights; (6) wooden uprights.

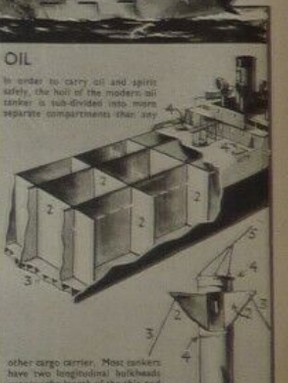




GRAIN

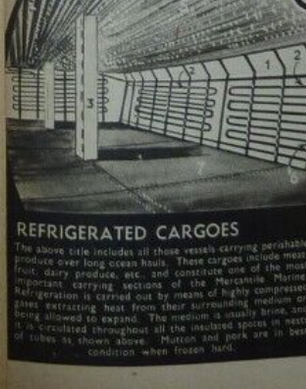
The three-island type is a useful grain carrier. Owing to its bulky nature, centre line divisions are fitted in the holds. These consist of fixtures (A) and movable portions called shifting boards (B). When the vessel is not carrying grain the shifting boards are removed to facilitate the carriage of general cargo (C). The boards fit into channels on the edges of the fixed centre divisions. Grain is a difficult cargo to ventilate and an unpleasant one to carry owing to the pungent smell given off. (D) Usual bulkheads dividing holds.

The above diagrams represent the structural types of ships. These have been evolved to suit the requirements of particular trades. All vessels, carrier was a single deck, full scantling vessel with little protection from wind and weather. This introduced later the three-island type with poop, bridge and forecastle, the bridge deck covering the machinery spaces, two wells being formed either end. Later these three erections were built into one continuous deck, thus forming the shelter deck. A tonnage opening consisting of doors, etc., is provided to obviate dues on totally enclosed spaces.



OIL

In order to carry oil and spirits safely, the hull of the modern oil tanker is sub-divided into more separate compartments than any other cargo carrier. Most tankers have two longitudinal bulkheads running the length of the ship and several transverse bulkheads dividing the ship up into over twenty separate compartments. (1) Longitudinal bulkheads; (2) transverse bulkheads; (3) double bottom; (4) tank hatches. Tanks are cleaned with heated steam. Care has to be taken to ensure proper ventilation owing to fumes given off. A special windsail (right) is hung over the holds for this purpose. (1) Opening; (2) wind-catching flaps; (3) guys securing flaps to deck; (4) hoops support this part; (5) wires supporting ventilator; (6) canvas.

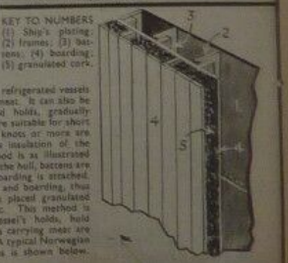


REFRIGERATED CARGOES

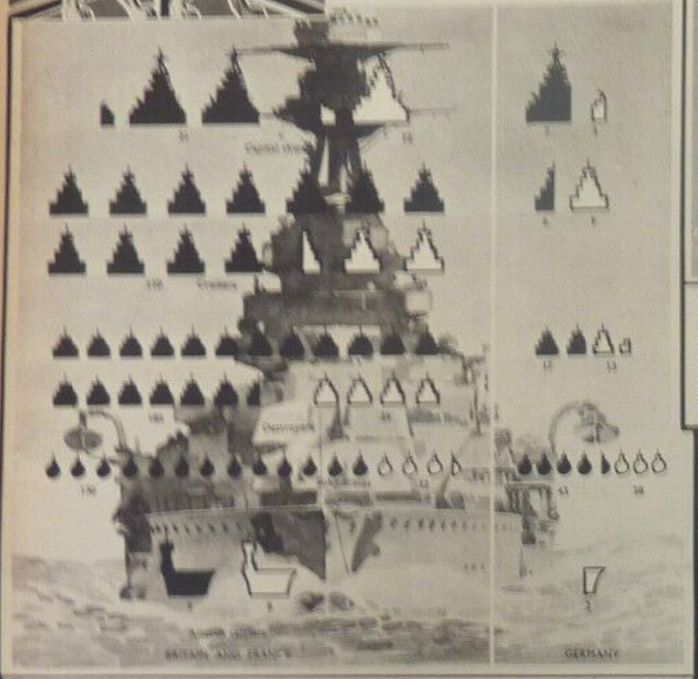
The above title includes all those vessels carrying perishable products over long ocean hauls. These cargoes include meat, fruit, dairy produce, etc., and constitute one of the most important carrying sections of the Mercantile Marine. Refrigeration is carried out by means of highly compressed gases extracting heat from their surrounding medium on being allowed to expand. The medium is usually brine, and is circulated throughout all the insulated spaces in nests of tubes as shown above. Mutton and pork are in best condition when frozen hard.

FRUIT

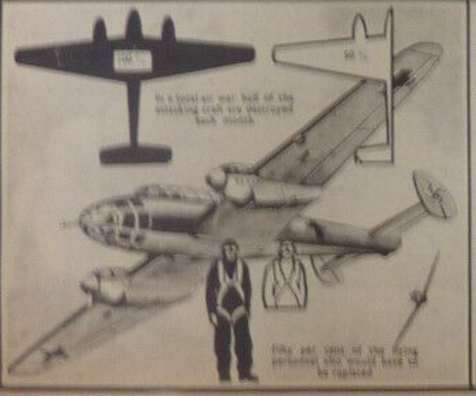
Fruit cargoes can be carried in refrigerated vessels in a somewhat similar way to meat. It can also be carried in specially ventilated holds, gradually opening in transit. This is more suitable for short runs where fast vessels of 16 knots or more are employed. In nearly all cases insulation of the holds is employed. The method is as illustrated (right). Against the frames of the hull, battens are fixed, tongued and grooved boarding is stretched. To this another set of battens and boarding, thus forming a space into which is placed granulated cork or silicate of cotton, etc. This method is employed throughout the vessel's holds, hold pillars, bulkheads, etc. Vessels carrying meat are insulated in a similar manner. A typical Norwegian fruit ship now with the Allies is shown below.



BEATING THE BLITZKRIEG



We still rule the waves. The illustration above shows the comparative sea power of the belligerents in February, 1939. Black silhouettes are completed vessels, white are building. Even if Italy came in on the side of Germany, the combined fleets of France and Great Britain would be sufficient to keep twice the force of our opponents in both the North Sea and the Mediterranean. Our chief danger is (as in 1914-1918) from the submarine, but by mounting this type of vessel along our convoy routes, the Nazis may succeed in sinking some of our merchant ships. This menace is already almost completely defeated by the convoy system, and nearly half the U-boats sunk have been destroyed by patrol ships, armed with guns and depth charges. When a submarine is under water its speed is only about 11 m.p.h., and on the surface it is an easy target for warships or aircraft. In the last war, losses were so heavy in the German submarine service that our enemies were unable to continue under-sea warfare on a large enough scale. Another menace to our shipping is the magnetic mine. Our ready reply to a typically Nazi kind of warfare has made this much vaunted "secret weapon" a definite failure. Air attacks on our warships and convoys have had some small success but complete domination of the seas by these means is impossible to Germany because they cannot replace losses in aircraft, crews, and petrol supplies sufficiently quickly. On the other hand, our present superiority in merchant and naval vessels is being increased faster than our opponents can sink them.



Germany cannot fight a total air war. Germany has a large air force which is certainly her best card in the present conflict, and to a great extent she depends on the striking power of her bombers. In a total air war great losses might be inflicted on the Allies, but the Nazis could not possibly keep it up unless they produce aircraft, fuel and crews sufficiently fast to make up for their losses. According to the Air Attaché, Germany in April, 1939, had 6,000 first-line aircraft, was building 600 planes a month and had recruited 2,000 pilots in 1938. In a total air war Hitler would have to make up for losses of 50 per cent a month. That is 3,000 planes and crews to man them. Here again the oil question crops up, for in 1938 Dr. Brinkmann, then Vice-Director of the Reichsbank, said: "What is the use of all these airplanes if we have no oil for them?" This was at a time when Germany was obtaining the greater part of her oil from the American continent.

WHY WE ARE AT WAR. Nazism brought Great Britain and France into the war, for Nazism is the enemy of civilization. Freedom for men and nations, and the right to live one's own life in one's own way will no longer exist in Europe if Hitler triumphs. After every encroachment on the liberty of unoffending non-Nazi peoples there has been heard the parrot cry "Germany has no more territorial claims in Europe!" This lie was in many others was for a time successful. Even after the attack on Poland many small nations still believed that neutrality was their best safeguard. The fate of Denmark and the advance into Norway, Holland and Belgium has proved otherwise. The Saar, Austria, Sudetenland, Czecho-Slovakia, Poland, Denmark, Norway, Holland, Belgium. Where next? It must be realized that these treacherous blows are dealt at Great Britain and France, whose democratic governments and peace-loving peoples cannot reply in the same coin. Our principles demand that we fight the war by direct attack upon Germany, and this we are doing and shall continue until our enemies sue for peace.

"The status of the worker in Germany is rapidly being lowered to that of a convict under sentence of penal servitude." This is from a report of the Trades Union Congress, and there are many facts to support it. German workers' pay envelopes were about 25 per cent lighter in 1938 than in 1928 (before the Nazi regime), and out of this they must pay heavy taxes, insurance, fees to Nazi organizations and "voluntary" contributions to Winter Relief. Standard of health is definitely lower and many foods were rationed in peace time. In August, 1939, Germany's food rationing was about the same as prevailed in Britain in 1918 after four years of war! Miners in 1939 rebelled against Goering's fifty-three-hour week, they tore down posters and at one pit only seventeen out of 5,000 turned up to work. Nearly 200 people have been executed for "treason" in peace time. This does not include the political purges. To every trained man bearing arms there must be ten workers on the home front, many of whom are Poles, Austrians, Czechs and others who have no sympathy for Nazism. Over all these hangs the shadow of the swastika, concentration camp, and firing squad. **We won the last war not only by the might of our arms but by Germany's collapse on the home front.**

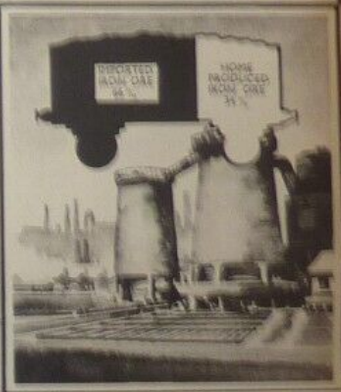
Germany still has to import (if possible) one-third of the food fats required by her population

The food question is as serious as any that Germany has to face. Our command of the sea is a guarantee that the Allies will be adequately fed, and the French in any case produce the greater part of their food at home. Fats such as margarine, bacon, lard, butter, cheese, table oils and pure vegetable fats constitute Germany's greatest food problem. In peace time one-half of these came from abroad, and after strenuous efforts to increase home production this was reduced to one-third. According to Germany's own statistics the best that can be hoped is that in the next few years this need can be reduced so that the deficit equals the needs of 13,000,000 Germans—one-sixth of the total population.

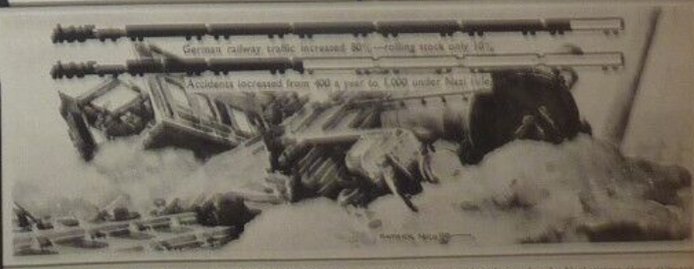
Each coin on this sketch represents two hundred and fifty million pounds of the yearly income of each country

Each belligerent country must pay for the war out of its national income. This means that both the Allies and Nazi Germany must pay for the war day by day, month by month and year by year. The illustration above gives the comparative national incomes, which means that the first three columns are combined against the fourth. "National income" means the total value of goods and services produced by the inhabitants of each country every year, and Germany has almost crippled herself by spending 25 per cent of its income on armaments before war broke out. Germany has less gold now than in 1918 after four years of war! With small reserves of gold our enemies will have great difficulty in obtaining essential raw material from abroad even from their friends. Our resources are far greater than in 1914.

All Russia's oil export amounts to only one-fifth of Germany's peace time needs. Petrol forms only a small part of the oil exported from Russia, and what is more, there are great transport difficulties. In peace time Russia's export of oil was brought to Germany's North Sea ports via the Mediterranean. This route is now closed and the obvious alternative route, the Danube, is largely ice bound during the winter. In addition Germany lacks the necessary supply of tankers, barges and tank wagons. At present Germany is endeavouring to increase her production of synthetic oil from coal, but this method is very expensive and uses up enormous quantities of coal, and would place great strain on German coal resources. If the Nazis were able (and this is doubtful) to seize the Rumanian oilfields intact, supplies would still be insufficient, for Rumanian and German oil production together would not supply nearly half the Nazis' wartime needs. **Most of the Rumanian oil yields very little aviation spirit.**



In 1914 Germany produced 76 per cent of the necessary iron ore, but now their richest ironfield, in Lorraine, is on the other side of the Maginot Line. Now she depends for more upon foreign supplies for in peace time the Nazis produced only 34 per cent of their iron ore. Once again Russia can give some assistance for the Russians need it all themselves. Even before the present war broke out Germany was scrap-iron and steel, and the country was thoroughly searched for scrap, even tram lines and park railings were commandeered.



The well-known weakness of the German railway system cannot be offset by the wonderful roads which have been built since the Nazis came to power. Apart from the petrol shortage Germany has only five-sixths as many commercial vehicles as we have—to serve an area two and a half times as great as Britain. From 1914-1918 Germany used, with great success, her splendid railway system, which enabled her to transport troops at great speed from one front to another, but under the Nazi system these railways have sadly deteriorated. Her increase in armaments has meant new replacements of track or rolling stock, actually traffic increased by 80 per cent but rolling stock only 10 per cent. In 1932—the year before Hitler came into power—there were 400 accidents on the German railways. This was bad enough, but by 1937 under the Nazi regime this figure had risen to over 1,400.

HOME GUARD CHART OF THE LEWIS GUN

BACKWARD MOVEMENT

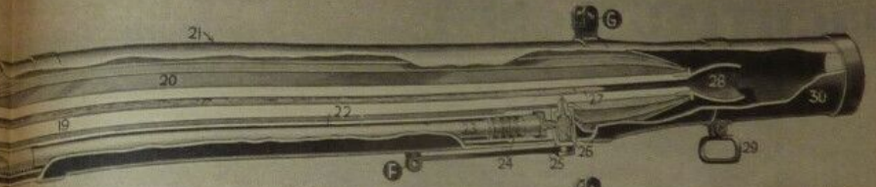
In the backward movement of the piston the recuperator spring is being wound up. The piston striker-post has unlocked the bolt by giving it a half-turn and carried it backwards together with the empty cartridge case. This case strikes the head of the ejector and is forced out of an opening in the right-hand side of gun. The feed arm actuating stud on top of the bolt is rotating the magazine clockwise.

GUN COCKED AND READY TO FIRE

The feed arm has placed a live round in position under cartridge guide. The return spring is held compressed owing to the sear being engaged with bent in rear of piston. When the trigger is pressed this sear is lowered and the return spring forces the piston forwards. This action takes the bolt forwards which pushes the live round into the breech, the striker post at the same time turning the bolt and locking it by means of the lugs. Breech is locked to take force of explosion. Striker post continues forward and fires the round.

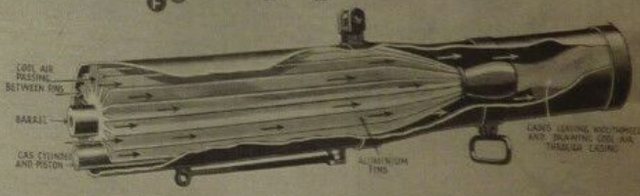
DESCRIPTION OF THE GUN

The .303 Lewis Light Automatic Gun is air-cooled, gas-operated, magazine fed. Weight, 28 lb.; length, 50 in. Magazine holds 47 rounds. Muzzle velocity of bullet 2,440 ft. per second.



COOLING

Some of the gases passing out behind the bullet choke the barrel mouthpiece, causing them to increase their pressure and expel all the air in front of them in the fore radiator casing. This causes suction behind them and draws cool air through the fins of the radiator. These aluminium fins being connected to the barrel throughout its length quickly draw the heat from the barrel and thus cools the gun. This is the most effective system of air cooling ever invented, and enables the gun to fire at a rate of ten rounds a second.



KEY TO PARTS

The principal parts which you will have to handle are lettered A to G as follows:

A—BACKSIGHT
The foresight blade is lined up in the centre of the aperture backsight when aiming. The adjustable leaf backsight is lying flat.

B—PISTOL GRIP
This is gripped by the right hand to steady the gun.

C—TRIGGER
This is squeezed gently to fire the gun. As long as there is sufficient ammunition in the magazine the gun will continue to fire automatically. To stop firing the trigger is released.

D—COCKING HANDLE
This is fixed to the piston and protrudes outside the gun. To cock the gun this handle is drawn to the rear.

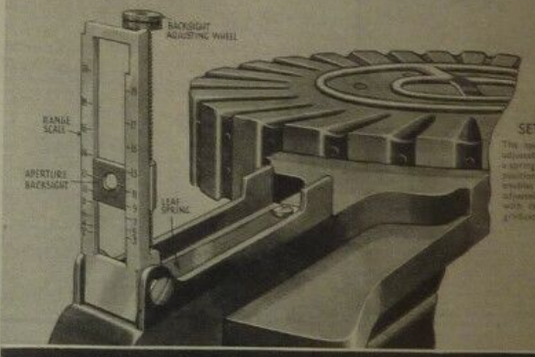
E—MAGAZINE
This holds forty-seven rounds and is placed on the magazine post and held in position by a spring catch.

F—GAS REGULATING KEY
This allows the gas regulator to be turned to prevent "seizing" of the threads.

G—FORESIGHT
The blade is protected by two wings and gives direction of aim.

Other parts of the gun are numbered as follows:

1. Butt
2. Butt sling swivel
3. Sear
4. Trigger spring
5. Return spring
6. Bent in piston
7. Striker post
8. Bolt
9. Bolt locking lugs
10. Bolt guide lugs
11. Guide grooves
12. Ejector tail
13. Feed arm actuating stud
14. Feed arm
15. Backsight adjusting wheel
16. Feed arm pawls
17. Cartridge case in chamber
18. Teeth of rack and pinion
19. Rifled barrel
20. Cooling fins of radiator
21. Radiator casing
22. Gas cylinder
23. Piston
24. Piston rings
25. Gas regulator
26. Gas chamber
27. Bullet
28. Barrel mouthpiece
29. Fore sling swivel
30. Fore radiator casing



SETTING THE SIGHTS

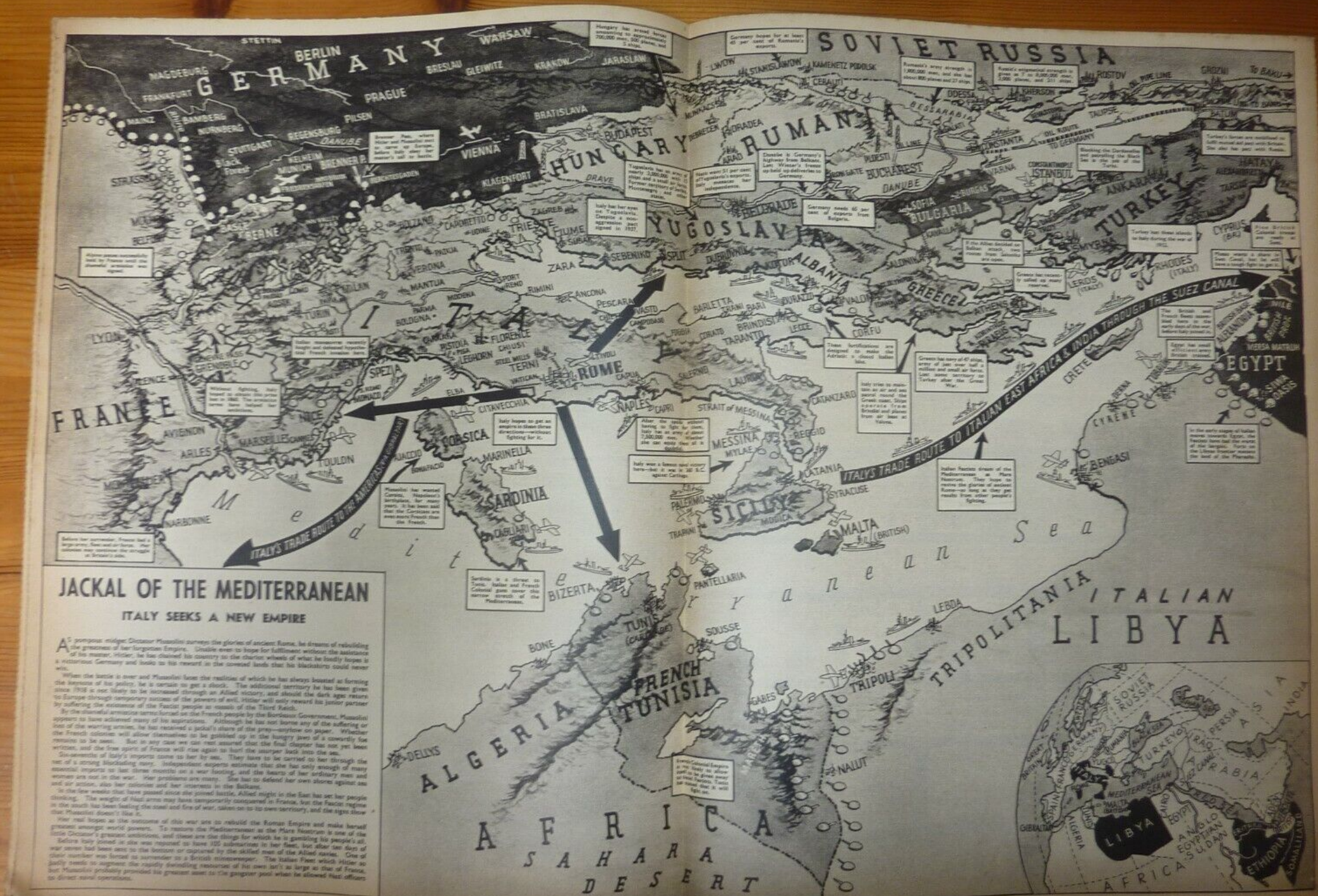
The aperture backsight is fixed to an adjustable leaf. When this leaf is closed by a spring catch underneath it is in the upright position. A small adjusting wheel enables the aperture backsight to be lowered until the engraved line coincides with the range required. The leaf is graduated from 300 yards to 2,000 yards.

TWIN MOUNTING

The use of Lewis guns in pairs and preferably used alternately increases the volume of fire and minimizes the risks of stoppages. When mounted in pairs on the A.A. mounting they are very effective against low-flying aircraft. The butt of the right gun is placed on the right shoulder and sights taken through that gun.

SINGLE MOUNTING

The single A.A. mounting is used as shown. The Lewis gun is the fixed on the ground and is supported by tripod legs fixed behind the fore radiator casing.



JACKAL OF THE MEDITERRANEAN

ITALY SEEKS A NEW EMPIRE

As pompous midget Dictator Mussolini surveys the glories of ancient Rome, he dreams of rebuilding the greatness of her forgotten Empire. Unable even to hope for fulfillment without the assistance of his master, Hitler, he has chained his country to the chariot wheels of what he fondly hopes is a victorious Germany and looks to his reward in the coveted lands that his blackshirts could never win.

When the battle is over and Mussolini faces the realities of which he has always boasted as forming the keynote of his policy, he is certain to get a shock. The additional territory he has been given since 1938 is not likely to be increased through an Allied victory, and should the dark ages return to Europe through temporary success of the powers of evil, Hitler will only reward his junior partner by suffering the existence of the Fascist people as vassals of the Third Reich.

By the shameful armistice terms forced on the French people by the Bordeaux Government, Mussolini appears to have achieved many of his aspirations. Although he has not borne any of the suffering or loss of the warring armies, he has received a jackal's share of the prey—anyhow on paper. Whether the French colonies will allow themselves to be gobbled up in the hungry jaws of a cowardly foe remains to be seen. But in any case we can rest assured that the final chapter has not yet been written, and the free spirit of France will rise again to hurl the usurper back into the sea.

Six-sevenths of Italy's imports come to her by sea. They have to be carried to her through the net of a strong blockading navy. Independent experts estimate that she has only enough of many essential imports to last three months on a war footing, and the hearts of her ordinary men and women are not in the war. Her problems are many. She has to defend her own shores against sea and air action, also her colonies and her interests in the Balkans.

In the few weeks that have passed since she joined battle, Allied might in the East has set her people thinking. The weight of Nazi arms may have temporarily conquered in France, but the Fascist regime in the south has been feeling the steel and fire of war, taken on to its own territory, and the signs show that Mussolini doesn't like it.

Her real hopes in the outcome of this war are to rebuild the Roman Empire and make herself greatest amongst world powers. To restore the Mediterranean as the Mare Nostrum is one of the little Dictator's greatest ambitions, and these are the things for which he is gambling his people's all.

Before Italy joined in she was reported to have 105 submarines in her fleet, but after ten days of war seven had been sent to the bottom or captured by the skilled men of the Allied navies. One of their number was forced to surrender to a British minesweeper. The Italian Fleet which Hitler so badly needs to augment the rapidly dwindling resources of his own isn't as large as that of France, but Mussolini probably provided his greatest asset to the gangster pool when he allowed Nazi officers to direct naval operations.

MODERN WONDERS

A NEW telephone instrument, primarily for use on board ship, gets its power solely from the speaker's voice and enables the user to call any five other stations in a network.

For the past six years, Canada has been the world's largest producer of platinum, the most valuable of all metals, replacing Russia in 1934.

Enough salt is contained in the oceans of the world to make a solid block measuring 4,800,000 cubic miles.

Almost 50,000,000 square miles of land are inhabited by men.

The sun, apparently the largest and brightest of all stars, is actually one of the smallest stars visible to the naked eye.

One inch of rain means more than a hundred tons of water to the acre.

Ninety-eight per cent of the total weight of so-called tin cans is steel, the other two per cent being the coating of pure tin.

Ceylon boasts some of the most astounding insects in the world—the "walking leaves." Their bodies are shaped and veined like leaves. When in danger they simulate the quiver of the foliage.

Radium generates enough heat in an hour to melt its own weight of ice.

Scientists are studying herring oil, which may prove useful as a drying oil in paints, also in soap-making and possibly for human food.

Linoleum is ordinarily made by mixing ground cork and linseed oil, and applying the mixture to burlap backing under pressure.

A grasshopper one inch long can make a standing jump from seventy to one hundred and fifty times its own length; an ordinary flea, with legs but one twentieth of an inch long, can make a jump carrying it seven feet in the air. To equal the latter's performance, a trained athlete with legs three feet long would have to jump over a building five hundred feet high.

If an elephant, proportionately to size, ate as much food as a mouse, it would consume ten tons of fodder every day.

Three drops of skunk musk will scent an area of about a quarter of a mile square.

In Japan, the silkworm, being responsible for the country's great silk production, furnishes whole or partial livelihood for 18,000,000 people.

Helium now costs about a penny per cubic foot; in 1917 the price was around $100.

Applying the gas mask principle of air purification, an American company has produced an odour absorber for use in industrial plants and other places where gases or vapours might cause harm.

Aviation petrol differs from ordinary petrol chiefly in having a higher octane rating and lower vapour pressure.

German chemists are reported to be making synthetic wool out of potato leaves, thereby opening a large new source of textiles.

Entomologists have taken to aeroplanes in order to catch insects high in the air, thus learning more about how pests spread.

The tungsten filament of an incandescent lamp gives off light at the highest temperature ordinarily encountered by man, or twice the temperature of molten steel.

Women are no more susceptible to X-ray burns than men, according to a dental surgeon, but women sometimes fail to remove cosmetics containing lead, mercury or heavy mineral salts, and these absorb the X-rays and permit the skin to burn more quickly.

The greatest depth to which a submarine has been known to descend and come up again is a little over four hundred feet.

The smallest metal tube yet made is 40/10,000th of an inch in diameter, with an inner bore of 17/10,000th of an inch.

One major wartime use for mercury is in making shell detonators.

PROPAGANDA BOMB

NO missile of destruction has been more used in the Second World War than the one that is dropped from the skies but does no bodily harm—the propaganda bomb.

Almost daily since the war began and until the great German offensive in May started, both German and Allied civilians have been bombed with leaflets attacking their Governments.

German propaganda had concentrated on France because the Nazi strategy called for an attempt to drive a wedge between the Allies.

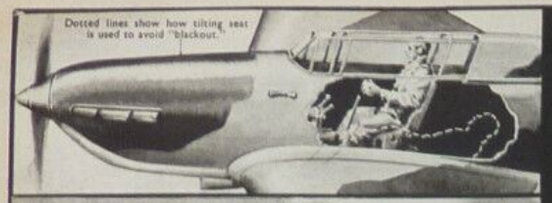
Designating England as the villain, Germany said to the French: "Why waste your lives fighting us? We have no quarrel with France. England, your pretended ally, is the real enemy. Why allow yourselves to be used by the perfidious British? And, remember, under Hitler, Germany is invincible."

To Frenchmen who had read *Mein Kampf*, Hitler's autobiography, this sounded decidedly convincing.

But war puts a great strain on people and many Frenchmen who pick up Nazi propaganda bombs, like the one above which was recently dropped in France

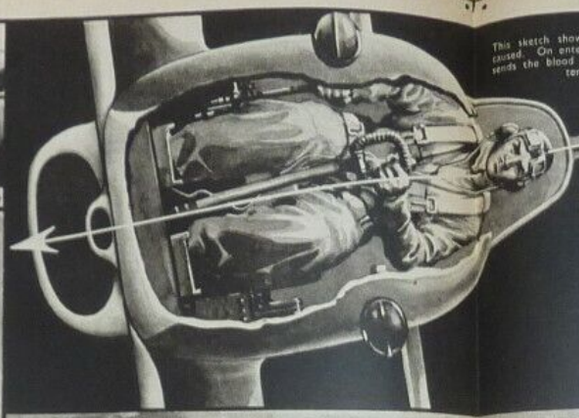
"BLACK-OUT"

EFFECT OF HIGH SPEEDS ON AIR PILOTS

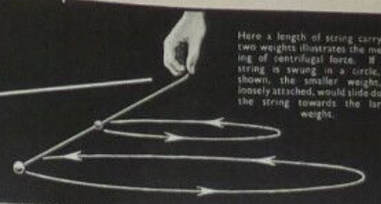


Dotted lines show how tilting seat is used to avoid "blackout."

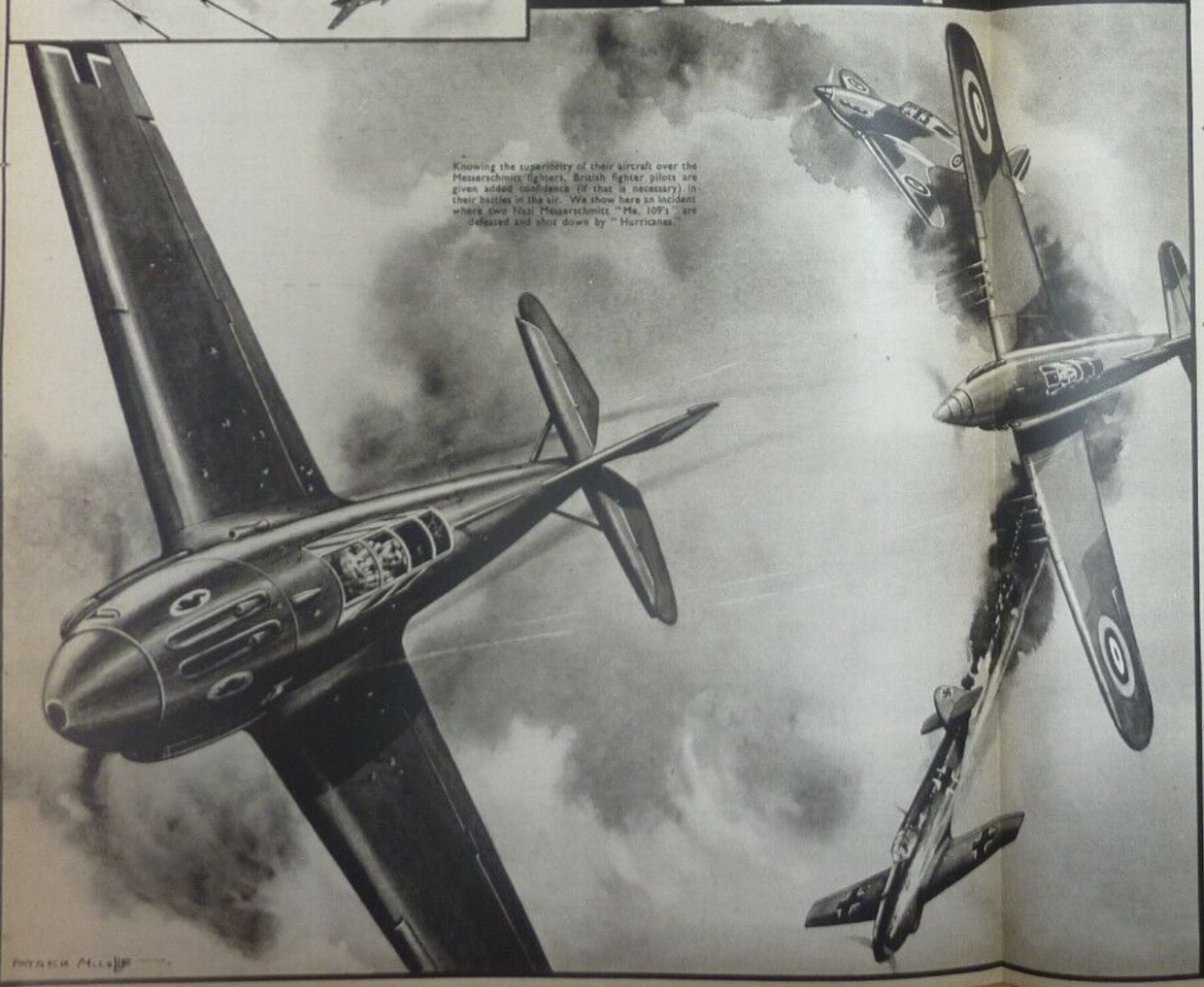
This shows how the British "Hurricane" has a smaller turning circle than the Messerschmitt, and is thus enabled to "get on to its opponent's tail."



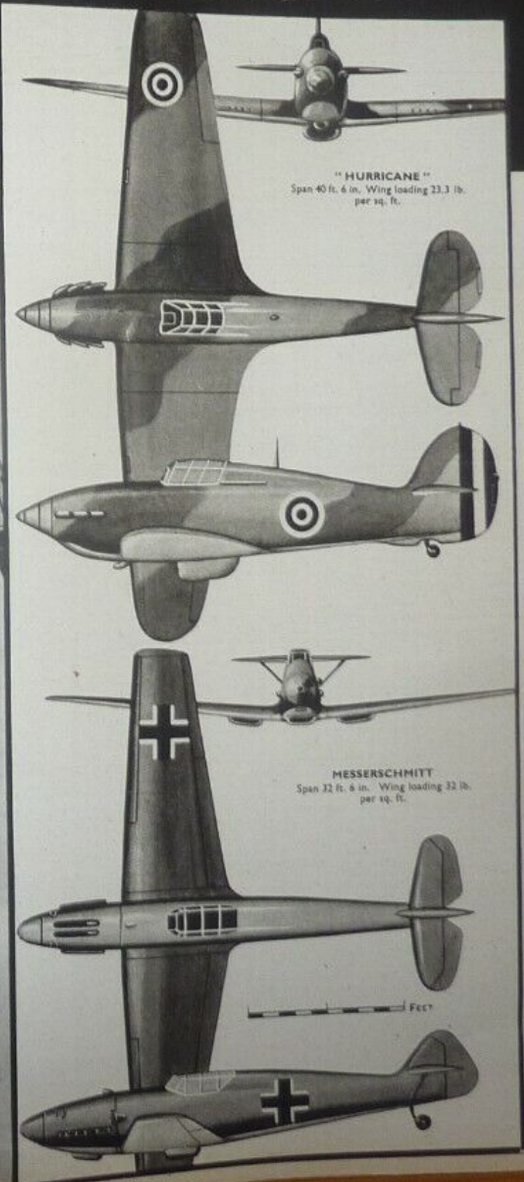
This sketch shows how pilot's "blackout" is caused. On entering the turn centrifugal force sends the blood from the pilot's head, causing temporary blindness.



Here a length of string carrying two weights illustrates the meaning of centrifugal force. If the string is swung in a circle, as shown, the smaller weight, if loosely attached, would slide down the string towards the larger weight.



Knowing the superiority of their aircraft over the Messerschmitt fighters, British fighter pilots are given added confidence (if that is necessary) in their battles in the air. We show here an incident where two Nazi Messerschmitt "Me. 109's" are defeated and shot down by "Hurricanes."



As most readers know pilots of high-speed aircraft are subject to a condition known as "blackout." We endeavour on these pages, to explain how this is caused.

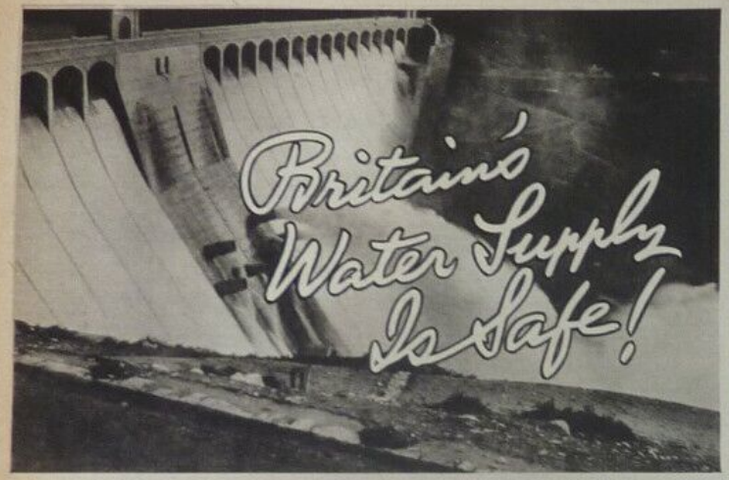
In the last war when the fastest military aircraft only attained a speed of 120 m.p.h. pilots were not affected, so that the main cause of "blackout" is due to the increased speeds at which modern aircraft travel. These increased speeds are attained because modern machines have more powerful engines than those used in the last war and are of better design. They are also, of course, more strongly built, for there is no doubt that if an "as-is" were propelled through the air at close on 400 m.p.h. it would simply fall to pieces, especially in a turn when centrifugal force would fold up the wings and hurl pilot and engine crashing down through the bottom of the fuselage.

It is really the centrifugal force exerted in a turn that causes the pilot to suffer from the condition known as "blackout." For instance, a fast aircraft travelling at high speed goes into a turn and as it "banks" the pilot is forced down into his seat and the blood in his head seeks to fly outward in the direction in which the aircraft was previously travelling, that is towards his feet, thus causing temporary blindness. This, by the way, is one of the reasons why men over a certain age are not nowadays accepted to be trained as pilots by the Royal Air Force.

Though the human element has to some extent failed, designers are attempting to overcome this difficulty. The only known method at the moment is for the pilot to have an adjustable seat, which falls back when a turn is being made, leaving the pilot in a prone position. With head and feet at the same level "blackout" is naturally not experienced, but there must be many difficulties from other points of view. All pilots, of course, do not suffer to the same extent, but it is known that the average man cannot turn at more than six times the equivalent of gravity. This is known as a "6-G" turn. A very strong man might perhaps make a "10-G" turn when lying prone.

Wing loading and span have a great deal to do with the size of the turning circle of an aircraft and, as shown above, the British "Hurricane" fighter has a smaller turning circle than the German Messerschmitt "Me.109." This accounts for the fact that British planes have a large preponderance of victories over their Nazi opponents. Wing loading, which is the amount of weight carried to each square foot of the wing, naturally increases with the increased gravitational pull exerted in the turn, so that in a fast "6-G" turn (six times normal gravity) turn the wing loading is increased six times and the higher the wing loading the larger the turning radius. As shown on these pages, the Messerschmitt "Me.109" has a wing loading of 32 lb. per sq. ft. and the "Hurricane" 23.3 lb. per sq. ft. which explains the smaller turning circle of the latter.

The ideal fighter that all aircraft designers are trying to produce will have high speed and comparatively low wing loading to enable the plane to make tight turning circles, so necessary in modern air warfare.



EVEN IN PEACE TIME OUR TAP WATER IS TESTED AND EXAMINED MANY TIMES DURING FILTRATION AND PURIFICATION NOW MANY ADDITIONAL PRECAUTIONS ARE BEING TAKEN

HORROR-MONGERS have told harrowing tales of what may happen to Britain's water supply. They foretell mass poisoning of the population through enemy action, and see in every dark night parachutists descending on our waterworks and spreading disease germs to kill us off as soon as we turn on the kitchen tap.

Whilst their grim foreboding might be justified as a possibility were precautions neglected, there's no need to spend sleepless nights worrying about it. On the outbreak of war the authorities took every step to ensure that our water supplies would remain available and pure, and a tremendous extension of the analytical and precautionary work has been carried out to maintain this essential service to the community.

How real a water shortage can be in wartime was recently illustrated when Italy joined her German ally. In parts of Libya water had to be transported over great distances to save the population from dying of thirst, and such an eventuality may yet face Italians who continue to live in these districts if lines of communication cannot be kept free.

In Britain, we take our water supply as a matter of course. One early experience of shortage is when a hot summer prevents us from watering our lawns, and even this only lasts, at most, for a few weeks. Supplying cities with water on a grand scale was pioneered by a Dutchman in 1582. His own countrymen were not interested in his scheme so he brought the idea over to London, and secured the right of taking water from the Thames for a period of five hundred years.

From the first pump erected by him on one of the arches of old London Bridge has grown the vast undertaking of the Metropolitan Water Board—largest water suppliers in the world. The original leasehold rest the Dutchman paid for taking water from London's river was ten shillings a year, and now one in every six of the population get their water from this huge undertaking. Most of London's water is still taken from the Thames, although other supplies come from the River Lea and wells dug through the chalky soil.

It could be only at the supply sources that the enemy might attempt to contaminate our water, and it is here that many precautions have been taken. But precautions alone are not the only reasons why our water is safe in wartime. People who imagine that the Nazis can poison or impregnate our water supplies with disease don't realise that throughout the process of purification analytical chemists keep up a constant, vigil, examining and testing samples to make certain that they are one hundred per cent pure.

Guards constantly watch our reservoirs to prevent parachutists or fifth columnists from interfering with the large tracts of water surrounding our big cities. Even should enemies succeed in wrecking pumping plant and other essential machinery employed to get the water into our cisterns, elaborate plans have been made to overcome the difficulties, and the population will be assured of getting this essential utility.

Water from the Thames or other source of supply is pumped into reservoirs and stored until it passes to the filter beds. These consist of layers of very fine sand, and the water is forced through this close mesh, removing the microbes as it passes through. Actually the sand is not effective in destroying the microbes until a thin film of mud has been formed on the surface containing the harmful bacteria. This film collects the microbes in the water, and is replaced with a fresh layer when saturated.

Before, during and after the filtration process chemists test the water in their laboratories, and from the stage when it is flowing lazily along the muddy banks of the Thames until it comes out in your tap scientists watch and test the supply. If any source is contaminated in any way it is not used until the cause has been ascertained, so that the water we get to drink is scientifically prepared to keep us healthy. Even the normal peace time work done to remove all germs should ensure that no harm can come to us through our water supplies, but since the war the additional precautions taken make the experts quite confident that the spread of disease will not succeed through attempts to tamper with our supplies.

The other consideration involves the wholesale use of poison. When we say wholesale we mean wholesale. The Metropolitan Water Board's reservoirs hold something like 19,000,000,000 gallons, and it would take about 10,000 tons of arsenic to poison such a huge quantity of water. Add to that the fact that Germany doesn't produce in a year nearly as much as that, and it becomes obvious that this form of poisoning isn't practicable.

It may be suggested that arsenic isn't the only poison that could be employed. Despite that the experts think that it is the only one likely to be used, and they give reasons for their opinion. Any poison used for this purpose must conform to certain conditions. It must dissolve in cold water, be nearly tasteless, and not betray itself by any colour. Few virulent chemicals other than arsenic meet the case, and for this reason it is the most likely to be attempted.

Suppose, for an instant, that the Nazis chose this way to attack the civilian population. On one large reservoir alone they would need to drop 3,000 tons of the poison before phony would be sufficient contamination of the water to poison people, and the opportunity to unload such a large quantity is remote. Assuming that 3,000 bombers each carried a ton apiece and succeeded in registering bull's eye shots with their poison bombs, they certainly could not hope to achieve the result without making their presence widely known.

The success of any such plan must rely on secrecy, and even the assistance of fifth columnists on the scale as Holland and Belgium would not compensate for the alert watchfulness of guards keeping watch at every danger spot.

But even if we suppose for one moment that all these plans unleashed death exactly on their targets there are still the analysts who would detect the presence of the arsenic and divert the poisoned supplies to channels where it could do no harm.

Before the war, plans existed for creating a great water grid system to link up the whole country. A vast network of interlinked water conduits would link north, south, east and west Britain. At regular intervals there would be boosting pumping stations to maintain pressure, and it was claimed that the scheme would prevent the colossal water wastage that now goes on.

All the evidence points to a safe, great and diverse free water supply for Britain.

MODERN WONDERS

MOBILE bath units are being used in the British Army. They are much in demand by the troops. These units can give hot shower baths to as many as seven hundred soldiers a day. Each unit consists of twenty shower compartments which can be set up in four sections of five showers each.

There are four vertical heaters in a unit, usually operated on oil drained as wastage from the engines of lorries. Each heater is connected by a hose to an overhead arrangement of sprays which may be operated separately by the bathers.

If a spider were to spin a thread round the earth, that thread, rolled into a little ball, would weigh about a pound.

The average silk stocking contains fifty miles of silk.

If you get on a scale on a hot day you will weigh more than on a cold day. An eleven-stone person will appear to gain a quarter of an ounce. The buoyant effect of warm air is less than that of cold air.

There are about one hundred and sixty hairs to a square inch on a man's face.

A diamond will turn permanently green if exposed to radium rays.

The greatest known ocean depth is in the Pacific, between the Philippines and Japan, where soundings of 34,000 feet have been registered.

Butterflies taste with their legs, which are 1,600 times as sensitive as the human tongue.

Snowflakes have been photographed by the thousand, but no two have ever been found alike.

Homing pigeons are capable of a speed of sixty miles an hour.

Floodlight by slot-machine has been introduced in an American city. Any body can have the new city hall floodlit for three minutes by dropping a small coin into a machine.

Every word spoken by the human mouth requires the simultaneous and co-ordinated use of seventy-two separate muscles.

There are about 44,000 thunderstorms daily throughout the world.

The lowest temperature ever recorded was at Verchojansk, in the interior of Siberia, on January 15, 1885. It was ninety degrees and a fraction below zero, Fahrenheit.

Waves of the sea reach heights ranging from twenty-five to fifty feet during the more turbulent storms. The highest wave ever recorded was eighty feet and was seen in 1922.

A camel accumulates fat in its hump as a food reserve. If a camel is overworked or underfed its hump becomes much flatter.

A humming bird makes seventy-five wing beats per second while flying, and forty-beats per second while hovering, according to data obtained with a rapid-action camera.

The human heart contracts 100,000 times a day.

Since sound needs a medium, such as air or water, it cannot be transmitted in a vacuum, which is absolutely noiseless irrespective of its surroundings.

The first parachute descent from aircraft was made by Andre Garnerin when he opened his umbrella and jumped from a balloon over Monceau Park, in Paris, on October 22, 1797.

Your brain records all the sensations of every part of your body, but it can feel nothing itself. You couldn't feel a surgeon slicing your grey matter.

Human teeth grow at the rate of 0.003 of an inch per day until they are fully developed.

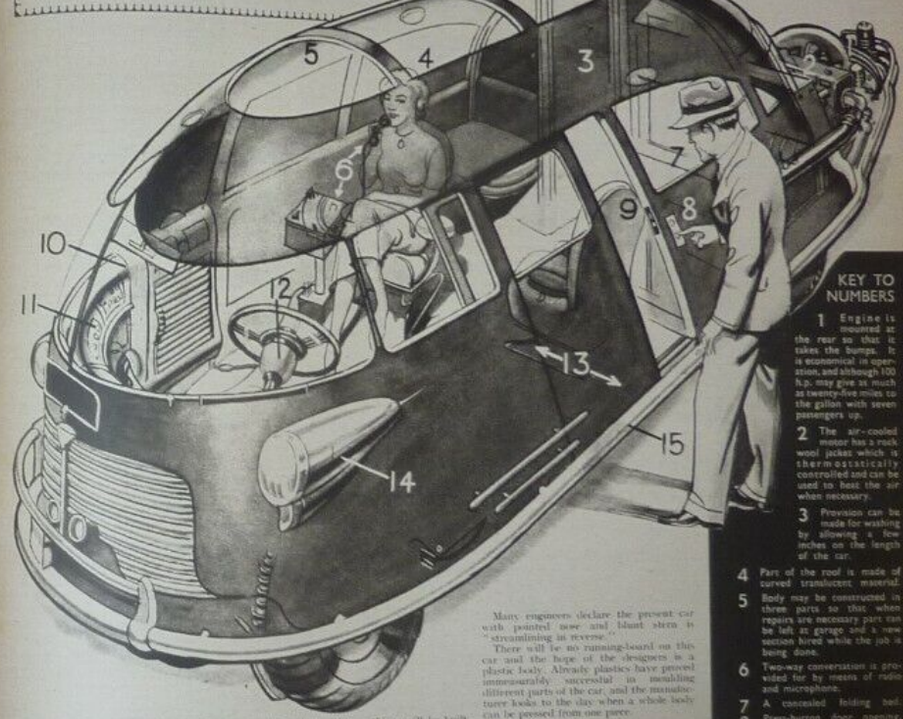
The hottest produce of nature is lava. When ejected from a volcano, its temperature is between 2,400 and 3,000 degrees Fahrenheit.

Oceans occupy seventy-two per cent of the earth's surface.

A Japanese scientist has invented a new cinema screen on which films can be shown in broad daylight. The screen is of celluloid painted black with over 50,000 raised points on its surface.

CAR OF THE FUTURE

MADE IN THREE SECTIONS—OWNER CAN LEAVE ONE PART FOR REPAIR AND HIRE A SECTION WHILE JOB IS DONE



KEY TO NUMBERS

1 Engine is mounted at the rear so that it takes the bumps. It is economical in operation, and although 100 h.p. may give as much as twenty-five miles to the gallon with seven passengers up.

2 The air-cooled motor has a rock wool jacket which is thermostatically controlled and can be used to heat the air when necessary.

3 Provision can be made for washing by allowing a few inches on the length of the car.

4 Part of the roof is made of curved translucent material.

5 Body may be constructed in three parts, so that, when repairs are necessary part can be left at garage and a new section hired while the job is being done.

6 Two-way conversation is provided for by means of radio and microphone.

7 A concealed folding bed.

8 Press-button door opening, and no running boards. Metal parts may be pressed from iron powder by similar process used in manufacturing plastics.

9 Light movable chairs take the place of the ordinary motor seats.

10 Flexible glass is fitted to the windscreens and windows, and concealed lighting is used.

11 Buttons regulate temperature and humidity.

12 Car may be driven from any position, and the controls passed from seat to seat.

13 There are no hinged or handles to the doors, and the car is built 6 ft. 6 in. wide to allow for sleeping. Spindleless springs made of rubber and steel make for comfort, and aeroplane landing equipment is fitted to each wheel. Tyres are protected against bursts.

14 New type of lamp is employed.

15 Body is seam-drop in shape—round at front, and pointed tail. There is a centralised belt of resilient material all round.

A CAR built in three sections so that repairs could be made on one part while the owner drove the other two-thirds, together with a hired third part—scores of motor prophets have given their ideas of the car of the future, but one new patent on the above lines introduces new ideas.

The patent has been granted to two Americans, Frank and William Fageol, of Kent, Ohio.

The car of tomorrow will be ultra-automatic, agree the engineers.

You will walk up to this car of the future, press a button and the door will open.

The interior will remind you of a comfortable room. You won't have to trip over seats and tunnels in the floor. Instead, the seats will be light, mobile. The floor will be wide and flat.

The car will probably be 6 ft. 6 in. wide.

A series of buttons will regulate the temperature and the humidity, so you may carry your "climate" with you.

Part of the roof will be made of a curved, translucent material which will admit the health-giving rays of the sun and filter out the glare.

Push a button and a concealed bed will roll out from a partition between engine and passenger compartments.

Washing facilities will be built in most of these cars with little added cost and by merely lengthening the body a few inches.

The engine, for one thing, will be built to take the bumps in the rear.

It will be a vastly better engine than is being built today, will operate more economically. It will be air-cooled as aeroplanes are today.

The controls of this car may be passed from seat to seat and you can drive where you like to sit, although engineers say the front seat is still the best place for the driver.

There will be little tyre trouble, and if there is any, a burst and flat-tyre guard will probably protect you.

Patents for this have already been taken out. This is in the form of a metal rim, welded to the inner side of each wheel and covering half of the tyre's inner side, to support the car when the tyre goes down.

This car will have knee-action or employ aeroplane-landing gear principles on all wheels to make riding easier.

The shift in the centre will move up and down in rubber. This spring may be even available on 1941 American cars.

The car of tomorrow, nearly all engineers agree, is going to look something like a mammoth streamlined teardrop, rounded in front, with a pointed tail.

The cowl will have been lost gradually and the teardrop shape assumed, not so much because of any practical effect of the streamlining but because the public will associate such shape with speed.

This will be due to aircraft design which is more and more going to influence the car.

Many engineers declare the present car with pointed nose and blunt stern is "streamlining in reverse."

There will be no running-board on this car and the hope of the designers is a plastic body. Already plastics have proved immeasurably successful in moulding different parts of the car, and the manufacturer looks to the day when a whole body can be pressed from one piece.

Ford, by 1941, if not sooner, is expecting to make his window frames of injection mouldings of plastic. Hot, synthetic resin would be squirted into several moulds at once in a large press.

A Cleveland company, using a kindred process, expects to be die-casting pistons by 1941. The 1941 car metal parts may be formed of iron powder, pressed together and baked.

Steering wheels have been made from a milk casein plastic. So you see the trend.

This is the way motor design is going in America. British industry is also trending still on this respect, and will remain so until the end of the war, but this may ultimately assist manufacturers when the time for starting up car building again arrives. Before the Great War we had cumbersome open bodies that gradually evolved through the early box-like saloons to the present-day graceful lines of 1940 models.

Now as we have to halt design and employ our resources on the far more vital job of winning the war, America will forge ahead and experiment with cars of the future embodying many of the ideas illustrated in the picture above. By the time we come into the business again, plastics and metal moulding may have become standard and car comfort may have been developed to an extent which we can only at present imagine.

(Condensed from the "Sunday Sun and Guardian." E.X.A.)

UNDER THE TYRANT'S HEEL

By LOUIS P. LOCHNER

AN AMERICAN JOURNALIST'S RECENT VISIT TO CONQUERED POLAND

Now starvation faces the Polish population. War has devastated the country and the invaders have taken their loot. They are seen giving housewives soup to keep them alive.

IT did not take many months for the German administration to make the Poles realize that the Reich is master of Poland.

Whatever the methods may have been for impressing the Poles with German authority, they obviously were effective.

Driving along the countryside, I often met Poles in uniform sitting on horse-drawn vehicles, or working out in the fields.

"They are disarmed former Polish soldiers and quite harmless," my German guide said. "Many of them had no other clothes except their uniforms, so we let them keep them.

"Officers, of course, still are treated as prisoners of war, but the common soldier who wanted nothing more than to return to his farm was readily discharged. He is free to move about at will."

Some 300,000 disarmed and disarmed Polish soldiers, I was told, are back home again, while some 300,000 are still prisoners in Germany.

Germans and Poles don't mix more than is necessary. The hotel in Krakow to which I was assigned bore a sign: "For German guests only." The German authorities had to arrange for permission for me to stop there, else the hotel manager could not have accepted me as guest.

The 3,000 German officials who hold the top positions in the administration, in so far as they reside in the new capital, Krakow, have their own casino or club in which to spend their evenings. The beautiful, artistic official residence of the Mayor of Krakow has been taken over for this purpose.

Here I found the German officials taking their evening meals, listening to the German broadcasts, playing ping-pong, cards and other games, or chatting together in groups.

Further evidence that the Germans consider themselves the overlords of the Poles was found in the presence of Hitler portraits and Hitler busts in the public buildings. The spacious central building of the School of Mines of Krakow, for instance, now the administrative building of the Government General, is featured by a large Hitler bust looking down from the head of the imposing staircase.

Another likeness frequently found side by side with Adolf Hitler's is that of Governor-General Hans Frank.

Governor Frank has had a meteoric career since Nazi accession to power. Herr Hitler's attorney in his many legal fights with the Republican regime of pre-1933 days, he was immediately placed in charge of revamping German justice to meet Nazi ideology. He created the famous slogan: "Whatever benefits the National-Socialist State, is right."

His big reward for faithful services came, however, when Herr Hitler appointed him Governor-General of Poland, responsible only to the Fuehrer himself. That was on September 27, 1939.

"Governor Frank sub-divided the Government General into four large administrative districts: centring in Krakow, Radom, Warsaw and Lublin respectively. In each of these four districts a German appointee of his holds supreme authority.

My general impression was that the Germans have come to stay—barring defeat—and that the top administrative positions will remain in German hands.

Governor Frank insists that the "Government General" still emerge as the "National Home of the Poles," just as they say Palestine is the National Home of the Jews. It is bound, however, to be some sort of vassal of Germany's, assuming that Germany wins or at least holds her own in the war.

The military is entirely German. The Hitler "SS" guards keep sharp control of the population to nip subversive efforts."

Homeless and starving children wanted disconsolately in the ruins that were once their homes. Mother, sisters and brothers were often killed beside them as the Nazi fury spent itself. Nothing but grief and hopelessness confronts a large proportion of Polish youngsters.

Following the Nazi racial creed, Jewish men and women were made to do the most menial work. Regardless of physical condition, old men and young were forced to dig trenches and do other hard labour.

DURING my two days spent in Krakow German traffic police were just teaching Polish "cops" how to direct the constant flow of vehicles and pedestrians. Of pedestrians there were plenty: the Poles seem to spend much of their life on the streets. Of vehicles, horse-drawn far outnumbered the motorized.

In fact, the German administration seems to take it for granted that such cars as travel the roads these days must be German, for all traffic signs put up by the Nazi authorities are in German only.

The streets are rapidly being identified by signs in both the German and Polish languages. At the railway station, the train announcer speaks German first, then repeats the announcement in Polish.

In the city's trams there are signs to the effect that Gentiles must sit on the right side and Jews on the left.

But how distinguish the two? Here, too, the German administration has found a way. Every Jew must wear a white armband with the Star of David imprinted upon it in blue. As this city of 280,000 inhabitants has 70,000 Jews, one cannot go very far without running into armbands.

In the realm of business, too, the distinction between Jew and Gentile has come almost automatically with the seizure of Poland by Germany. Jewish shops are marked with the Star of David; Gentile stores usually have a placard, "Aryan undertaking."

Then there is a third group of commercial establishments which are run by German "trustees." So far as I could learn, most of the larger Jewish businesses have been taken over by these trustees.

I tried to do some shopping soon after my arrival in the city. I soon gave it up. Everywhere I was asked for my ration card. Of course, I had none. But the question seemed awfully familiar after eight months of sojourn in war-waging Germany!

On the huge market-place there was the familiar spectacle: hundreds of people standing about and gossiping. The purchases were by no means proportionate to the number of people standing about. But that has always been thus as long as I can remember visiting Polish cities.

At various places on the market square, placards were posted indicating top prices for various commodities which may not be exceeded.

I entered the famous church on the square. What struck me particularly was the fact that most of the worshippers—and there were many of them—were young people, boys and girls in their upper 'teens. I could not help but wonder how many of them had fathers in German captivity, while their mothers probably volunteered as farm hands for work in Germany.

(Condensed from "The Christian Science Monitor," Boston, U.S.A.)

Terrified Polish peasants crouched in this bomb crater for days. When they were at last discovered it was only to be faced with a German soldier's battery of questions. A conquered people were subjected to every horror of war.

CAN the LABORATORY CREATE LIFE?

By V. E. COLLINGS

THERE IS NO REASON WHY LIFE ON A PHYSICO-CHEMICAL PLANE SHOULD NOT BE CONSTRUCTED BY THE CREATION OF LIVING CELLS

OUT of the steaming pie of primeval mud in a billion-year-old past Nature, super-chemist and physicist, every necessary ingredient to hand, began experimenting with the production of life from lifeless matter.

The process was no lucky chance, shot-in-the-dark attempt, but a gradual change through ten thousand years from a mass of gas, a rock, a clod, through a stage between the animate and inanimate to the living slime that we call protoplasm. In short, life. And life bringing with it that equally mysterious twin, death.

Today the scientist tries his hand at the same game. But the laboratory-made man has become a bogy. Something that is just within reach but never quite in our grasp. We forget in our experiments that in addition to the necessary chemicals there is that something called "Evolution," the unknown element which cannot be bought, sold, split in the cyclotron or handled in any way, but is none the less the underlying essential for the manufacture of the extraordinary thing called "life."

Summing up this matter of the possible creation of life in the laboratory, Waldemar Kaempffert, in *Science Today and Tomorrow*,* states that "it is now recognized that forces are at play within and without the (living) cell which enable it to adapt itself in a limited degree to its environment, and because of this discovery there is no reason why life on a physico-chemical plane should not be constructed by the creation of living cells."

But to construct even a robot the engineer needs a blue-print, he must know exactly what he is to do and how to set about it. How much more necessary is it for the chemist to know the vital properties of the elements with which he has to work and a detailed plan of this "life" which he is to create.

STUDYING SIMPLE FORMS

As Kaempffert says: "Little is known about life generators, and that is one reason why science is still baffled by the mystery of life. The more simple animal and plant forms are studied, the deeper is this mystery. Enumerating the functions of the simplest living organism and then insisting that a structure is alive if it performs these functions, is useless."

For example: Living things move spontaneously, you say. So does a railway engine. Living things eat, lifeless matter does not. Yet if you bring a drop of chloroform near a glass particle coated with shellac the drop flows round the particle, devours it, digests the shellac and then actually rejects the indigestible glass particle! What living organism could do more? Well, you may add in desperation, animals and plants grow. Lifeless matter does not, surely. Wait a moment, however, just "throw a lump of copper sulphate into a dilute solution of potassium ferrocyanide. A brown envelope develops. It throws out upward-growing runners. In half an hour the solution is filled with a 'plant' that closely resembles seaweed—something that has grown in a very real sense. The weight of the artificial plant may be 150 times that of the original copper sulphate. Dozens of inorganic crystals thus grow and reproduce their kind. Like any living thing they need but a supply of the requisite pabulum. Even the process of self-division whereby a simple cell reproduces itself can be mimicked with solutions of common table-salt containing suspended carbon particles."

The experimenter is in a fix, admittedly. He has run through what he considers the exclusive attributes of life and finds that so-called "dead" matter may have them, too. That all life comes from life has been an accepted doctrine in science for two centuries. "Yet there was certainly a time when the earth was too hot to support life. Clearly, nature must have succeeded in accomplishing what the biochemist is attempting now—to create life out of matter that is not alive. So perhaps our scientific Frankensteins are not as mad and vaunting as they seem to be at first glance."

The simplest protoplasmic cell, a protozoon, has been called "immortal" for it reproduces by the easy process of splitting in two and splitting again in two and so on and on and on *ad infinitum*. But we now come to a strange fact. Although the human body is a collection of several billion body and germ cells its immortality is regrettably in question. Although for many years a man can build new body cells faster than they break down, the day comes when his last living cell finds it impossible to feed itself, extract energy from something outside of itself and divide in two to reproduce itself. The body is then "dead."

RIDDLE OF DEATH

But what is death? This matter is of extreme importance if we are to understand life, for if we only knew what happens when a cell dies or is killed we would know what life is. Life and death are so closely bound up together that the key to one is the answer to the riddle of the other.

That is why biologists are as much concerned with dying as with living. They seek to discover why the individual cells of a man are deathless, yet he as an individuality dies. If more were known about the deathless protoplasm it might be possible to prolong human life."

"Suppose we attempt to construct a cell. First of all," we are told, "we must find out of what it is composed. We analyse protoplasm just as we would water or a rock, only the task is much more difficult. What does the analysis show? Oxygen 72 per cent, carbon 13.5 per cent, hydrogen 9.1 per cent, nitrogen 2.5 per cent. There are also traces of chlorine, phosphorus, sulphur, sodium, calcium, silicon, iron manganese, iodine, magnesium and fluorine. Protoplasm is composed of much the same stuff as the earth itself—evidence that it sprang from the earth. We mix all these chemical components together in just the right proportions. And the result? 'A laboratory mud-pie. Not a sign of life. Nothing that even remotely resembles protoplasm as an organism. Life cannot be compounded like a drug-store prescription."

MAKING A MAN

Then come the experts, the colloidal chemist, the fermentation chemist, biochemist and physicist each with his contribution towards the solution of the mystery, but still the vital spark is missing.

"Could an infinitely wise physicist order the necessary chemicals today, and tomorrow put together a synthetic man?" asks an English scientist, L. L. Whyte. "and if not, why not?" He invites us to watch this imaginary physicist at work. This is how he puts it. "He has completed the first colloid he will require, and is starting on his first organic synthesis. But this infinite wisdom does not give him eternity within a minute, and we notice he is getting on more slowly. While the combination of the first molecules took only about a thousandth of a second, once he had the apparatus ready the simplest colloid took about a second.

"The organic colloid took about a minute; it seems that Nature won't work faster than that. She has her own rhythm and won't be rushed. If we wait patiently till the end of the day our friend may have his first speck of protoplasm and all the skill in the world would only have helped him to make more of it, not to have got any further in his game of evolution."

If our experimenter had worked out for us a table of the estimated minimum time required by the synthetic processes of nature to attain various evolutionary stages it would read as follows:—

Simple organic compound, 1-1,000th second.
Simple colloid, 1 second.
Protein, 1 hour.
Primitive protoplasm, 1 month.
Simplest unicellular organism, 10 years.
Flagellate, 1,000 years.
Mammal, including Homo sapiens, 1,000,000 years.

The meaning is clear. Every chemical reaction needs time. The greater the number of atoms that have to settle down together the longer the time must be. The man who tries to fashion a human being inside the four walls of a laboratory would need himself to be immortal. The very best, we are told, that the physiological chemist can do is to create some very low form of life, control its environment for many generations, and let evolution take its course.

BEATEN BY TIME

To many scientists, old age is looked upon as a disease. Experiments made by Carrel support this view. It is true that his world-famous chicken heart is apparently immortal, but this is, we are told, only because its cells feed on young embryonic matter and because the wastes thrown off are washed away. Heart tissue does not thrive so well on old plasma, and it would seem that old organisms produce some substance which saps their vigour, and that ageing is indeed a form of disease. The "elixir of life" for which science has searched so long may well be the "elixir of youth."

After all, the problems that face the scientist who seeks to solve the secret may be no more formidable than those overcome by the physical chemists in discovering that the atom is in itself a system composed of a nucleus and of outer electrons. Perhaps some vital discovery will be made about protoplasm, "some undivided attribute which will lead the biochemist to frame a new theory of life."

"Life is energy," we know. The atom is energy. If mathematics and physical chemistry can tear away the veil that now enshrouded the mystery of the atom's source of energy, what may they not do for the exact interpretation of life? They will enable the biochemist to see the molecules in protoplasm in their proper relationships, to understand better than he does now the functions of the enzymes, surface tension, and other forces that govern the life of a cell, and to specify on paper just how he must go about the business of synthesizing the lowest form of cellular life.

Man, who today is so expert in dealing out death in various forms to his fellows, is still incapable of creating life. He has to own himself completely beaten by the element of time. Only an International Institute of Evolutionary Research under the most stable League of Nations would hope to create an artificial man, and even then man could hardly take the credit, for time would have done more than man.

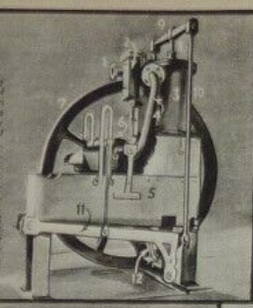
* "Science Today and Tomorrow," by Waldemar Kaempffert. Nicholson & Watson, 10s. 6d.

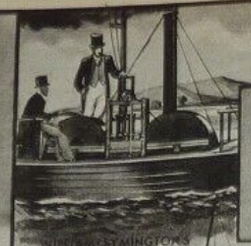
STEAM POWER AT SEA

FOR centuries the world's shipping was dependent for its movements on natural forces. About 100 years ago, however, man began to think about other forms of propulsion. As early as 1630 David Ramsays was granted a patent for a steam engine to propel barges or boat, and from then on steam began slowly to play its part in maritime affairs. Hulls, paddles, experimental engines and craft. William Symington, Watt, and the American, John Fitch, all contributed bulled boat driving two paddle wheels between Edinburgh and Leith. Fitch's steamboat was launched in 1811, and she began her service on the Delaware. Fitch's craft may be regarded as the legitimate forerunner of the following year. This ship, and her three sister ships of the present, despite the inroads of the Diesel engine, steam still holds its own at sea. Turbines drive our mightiest warships and liners. Reciprocating engines, old reliables, propel a large percentage of our cargo tonnage today.

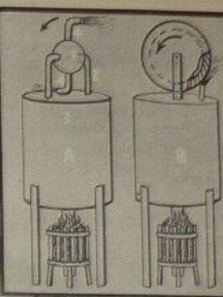
PADDLE AND RECIPROCATING ENGINES

The first steamer to run commercially in Europe was Henry Bell's *Comet* of 1812. The engine was built by John Robertson of Glasgow. The engine was set low down in the hold, and the boiler on the starboard. The boiler was of low pressure type set in brickwork. The engine is shown on right. 1, Steam inlet; 2, Valve chest; 3, Cylinder; 4, Exhaust to condenser; 5, Condenser; 6, Air pump; 7, Flywheel; 8, Piston; 9, Crosshead; 10, Connecting rod; 11, Half-side levers; 12, Connecting rod to shaft. During this early stage the flow of Boulton & Watt, introduced, in 1820, the side lever engine which remained in use until 1860. Direct acting oscillating and other engines followed, all for driving paddle wheels.



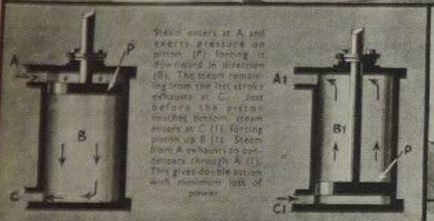


WILLIAM SYMINGTON'S PADDLE BOAT



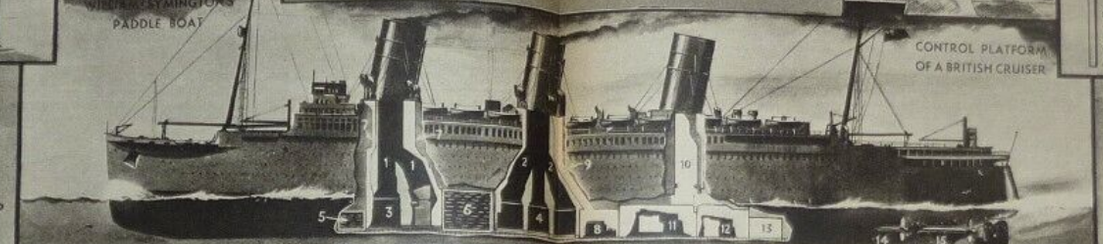
TURBINES

The turbine as applied to marine propulsion is comparatively recent as compared with steam piston type of engine. The theory of the turbine is not new, however. A reaction engine (A) was invented by Hero of Alexandria, about A.D. 50, and the impulse machine (B) was produced by Giovanni Branca in 1629. These two inventions form the basis of turbine machinery. The modern marine turbine being a combination of both. Hero's engine consisted of a hollow ball (1) mounted so that it could revolve on two pivots (2), one of which was hollow, leading down to a simple heater below (3). The ball was fitted with two hollow spokes on either side (4). Steam rushed up (2) into the hollow ball and out at (4). The pressure on the portions of the nozzles opposite the orifices was unbalanced, and thus drove ball and spokes round.



Steam enters at A and exerts pressure on piston (P) forcing it downward in direction (B). The steam remaining from the last stroke exhausts at C. Just before the piston reaches bottom steam enters at C (1), forcing piston up B (1). Steam from A exhausts to condenser through A (1). This gives double action with minimum loss of power.

The principle of the steam cylinder common to all types of modern marine engines is shown above. The cylinder consists of a strong iron or steel tube of considerable thickness. Covers or caps are fitted to top and bottom, being perfectly steam tight. Suitable openings are made at each end for the inward and outward flow of steam. Inside is the piston which can move up and down, but fits steam tight. A special gland packing is situated around the opening in the cylinder through which the piston passes.

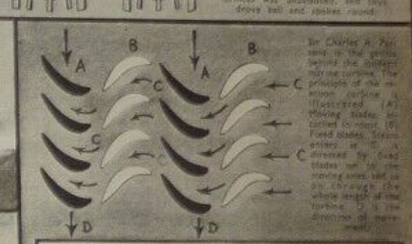


Above is large western ocean liner. 1, Forward uptakes; 2, After uptakes; 3, Forward boilers; 4, After boilers and boiler rooms; 5 and 6, Oil fuel tanks; 7, Air shafts to boiler rooms; 8, Generator room; 9, Air shaft; 10, Air shaft and ventilator to engine rooms through dummy funnel; 11, Forward turbine room; 12, After turbines; 13, Engineers' workshops; 14, Outer port propellers; 15, Inner port propellers.

CONTROL PLATFORM OF A BRITISH CRUISER

The first Cunarder, the paddler *Britannia*, and the first steamer to carry the American mails.

Here is the first turbine-driven ship, the *Turbinia*, built by Sir Charles A. Parsons in 1894. She reached the then astounding speed of 34½ knots.



Sir Charles A. Parsons is the pioneer behind the modern marine turbine. The principle of the reaction turbine (A) is illustrated. (A) Moving blades attached to rotor (B). Fixed blades. Steam enters at A, is directed by fixed blades on to the moving blades, and so through them. It changes the whole length of the turbine. D is the direction of rotor movement.

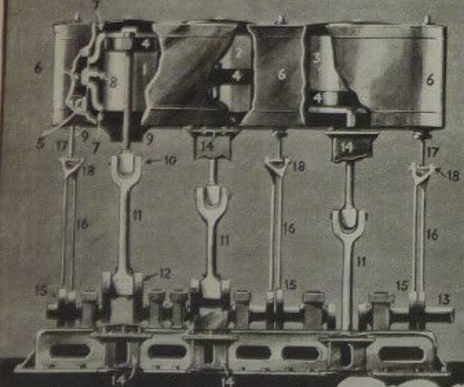
Considered generally a turbine is a series of large circular disks on which are attached a great number of small vanes of curved section. The steam jet passing as shown above, causes the vanes to rotate. The disks being connected to the propeller shaft which runs the length of the turbine propulsion is effected. The one disadvantage of the turbine is that it cannot be reversed by changing the direction of the steam. This is overcome, however, by the use of a group of blading arranged for astern working, which is attached to the rotor of one or more of the turbines comprising the set.

WATER TUBE AND FIRE TUBE BOILERS

The water tube is used almost exclusively in warships today, and also most large liners, and many other types of merchant vessels. The boiler above is of the well-known Yarrow three-drum design. In 1889 Sir Alfred Yarrow had patented his design. The Yarrow depicted is typical of most water-tube boilers, subject to various modifications such as the introduction of additional water drums, superheaters, oil firing, etc. A modern Yarrow boiler has 12,444 square feet of heating surface with a working pressure of 425 lb., with steam superheated to 725 degrees Fahrenheit. 1, Fire door; 2, Grate doors; 3, Grate; 4, Boiler floor; 5, Water drums; 6, Feed water; 7, Water tubes connecting with steam drum; 8, Steam drum; 9, Tube cleaning door; 10, Inspection plate; 11, Boiler casing; 12, Casing supporting frame; 13 Uptakes; 14, Arrows represent direction of furnace flames and hot gases.

Left is a section through the lower part of an oil-burning boiler. The burner A sprays burning oil into the furnace. Hot air passes to it through B. A large number of these sprayers, as they are called, are installed in a modern boiler.

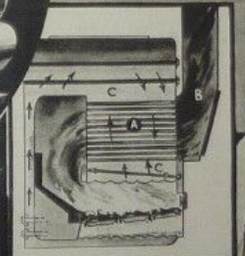
Right is a Scotch boiler or fire tube boiler. This boiler has been standard practice in the merchant service for many years, and is still a favourite for reliable service. Its principle is the opposite to the water tube boiler. Flames and gases pass through fire tubes at A and out through the uptake (B). Feed water surrounds these (C) and receives its heat thereby. The arrows represent circulation of the water.

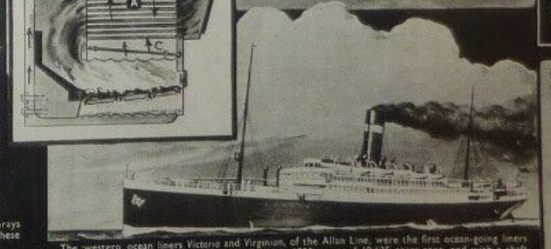


The modern marine engine of piston type is known as a triple expansion or quadruple expansion engine. A simplified drawing of one showing the principle upon which it functions is shown (left). This is still the basic type of cargo ship engine. Although faced with rivalry from the internal combustion engine, this has tended to improve the type and many refinements in operating valves and steam supply have been effected with resultant economical advantages. Many vessels equipped with superheated steam oil-fired boilers and the latest triple expansion engines can hold their own with the modern Diesel ship. A quadruple expansion engine has four cylinders. The condenser is placed at the back of the unit.

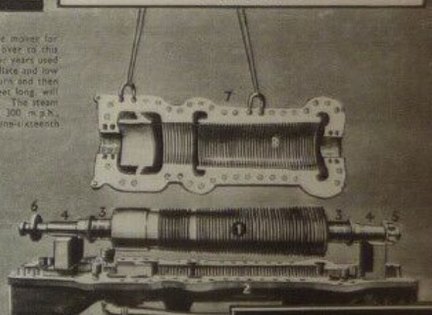
The action of reciprocating engines depends upon the expansion of steam. High pressure steam first enters the high pressure cylinder (1) then passes to the intermediate (2) and then the low pressure (3), expanding at each stage until it passes on to the condenser. The slide valves are adjusted by altering the positions of the link and rods. 1, High-pressure cylinder; 2, Intermediate cylinder; 3, Low-pressure cylinder; 4, Pistons; 5, Steam chest; 6, Slide valves; 7, Steam entry ports; 8, Steam exhaust ports; 9, Steam light packing; 10, Crosshead; 11, Connecting rods; 12, Crank, 13, Propeller shaft; 14, Supporting standards; 15, Eccentrics; 16, Eccentric connecting rods; 17, Slide valve piston rod; 18, Link motion and reversing gear.

H.M.S. *Terrible* above, an armoured cruiser built in 1895-1897 of 14,200 tons displacement, along with her sister ship the *Powerful*, were the first large warships in the British Navy to be filled with water-tube boilers. These were of the Belleville type, named after their French designer. Each boiler comprised a set of continuously inclined tubes passing ten times to and fro over the furnace, and opening at the upper end into a steam drum. Their lower ends were connected to a feed water drum. They developed 220 lb. per square inch pressure. The ships had a speed of twenty-two knots on 25,000 h.p.

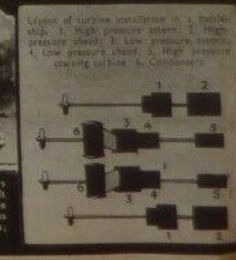




The western ocean liners *Victoria* and *Virginian*, of the Allan Line, were the first ocean-going liners to be fitted with turbines. They were built in 1905, were of 10,635 gross tons, and with a shaft horse power of 12,000, developed a speed of nineteen knots. In the same year followed the Cunarders *Carmania* and *Caronia* fitted with turbines driving three shafts, and in 1907 the famous *Mauretania*, and her ill-fated sister, the *Lusitania*, were equipped with turbines driving four screws, the first ships to be thus equipped.



Principal parts of a turbine. 1, The rotor and the thousands of blades mounted on their disks; 2, Lower portion of casing; 3, Labyrinth packing to prevent escape of steam; 4, Shafts; 5, Coupling for transmitting drive; 6, Thrust collar; 7, Upper portion of casing; 8, Fixed blades.



Layout of turbine installation in a battleship. 1, High pressure astern; 2, High-pressure ahead; 3, Intermediate; 4, Low pressure ahead; 5, High pressure cruising turbine; 6, Condensers.

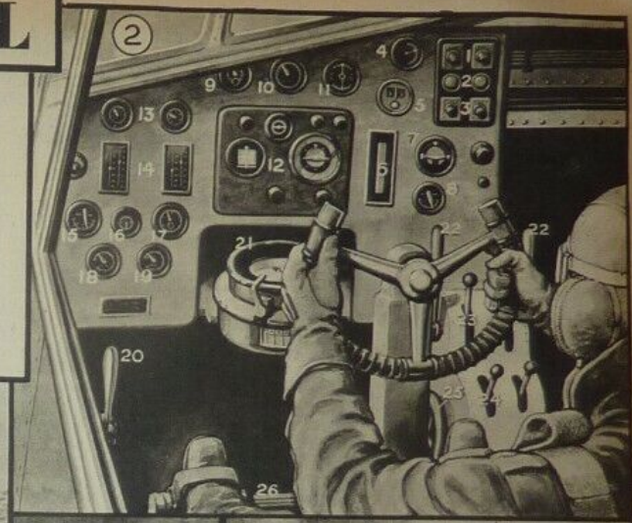
SECURITY PATROL

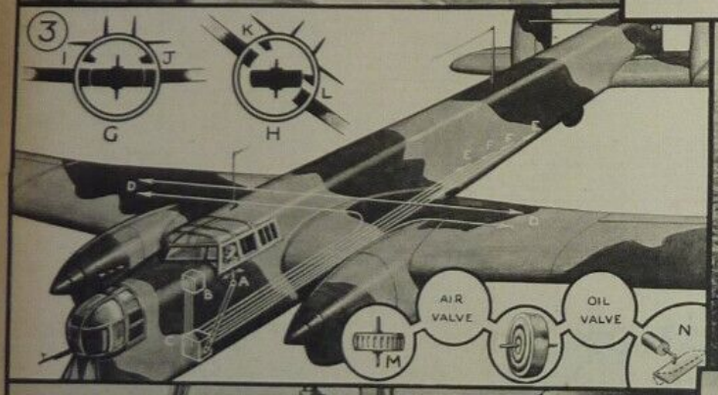
IN Fig. 1 the aircraft, a "Whitley" bomber, is heading out over the sea. Before leaving, the pilot and crew have signed a form stating that they carry no papers or any article that might be useful to the enemy. Some idea of the number of instruments used by a pilot is given in Fig. 2. 1, are the engine starter switches; 2, engine tell-tale lights; 3, engine ignition switches; 4, flap indicator; 5, directional gyro.; 6, fore and aft level; 7, artificial horizon (gyro); 8, fuel indicator; 9, air speed indicator; 10, rate of climb indicator; 11, turn and bank indicator; 12, automatic pilot; 13, oil pressure gauges; 14, engine revolution counters; 15, fuel gauge; 16, oil temperature gauge; 17, air speed indicator; 18 and 19, engine boost gauges; 20, automatic pilot control; 21, compass; 22, cut-out levers; 23, engine throttles; 24, carburettor controls; 25, tail trimming wheel; 26, rudder bar.

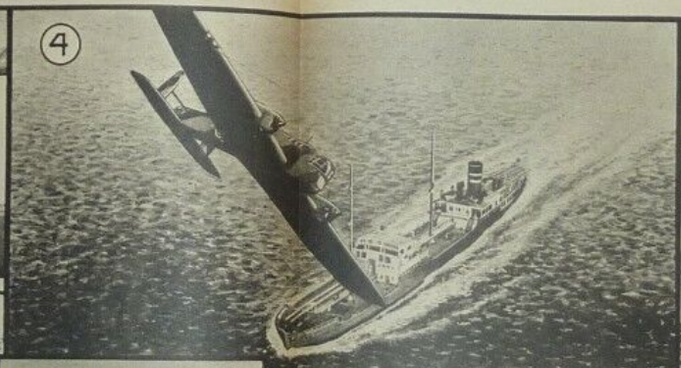
The automatic pilot control (No. 20) is always used on a patrol of this kind, and some idea of its working is given in Fig. 3. As is well known, the automatic pilot is controlled by a gyro wheel, and the working of this is shown in Figs. G and H. At G the plane is horizontal and the two openings (I and J) in the air valve surrounding it are open. At H the plane is tilted to one side. As the gyro maintains its horizontal position this closes the opening L, but K remains open. Changes in the air flow through the valve affect a diaphragm which actuates a rod controlling a valve which admits oil under pressure to the "Servo" unit pistons controlling the ailerons, etc. This arrangement is shown pictorially from M to N in the lower part of the illustration. The disposition of the controls is shown by white lines superimposed over the drawing of the aircraft. A is the automatic pilot control (No. 20, Fig. 2); B, automatic pilot panel (No. 12, Fig. 2); and C, the box containing the "Servo" unit. This is usually near the pilot's feet. DD are the aileron controls, EE the rudder controls, and FF the elevator controls. All of these are actuated by pistons (N) in the "Servo" unit.

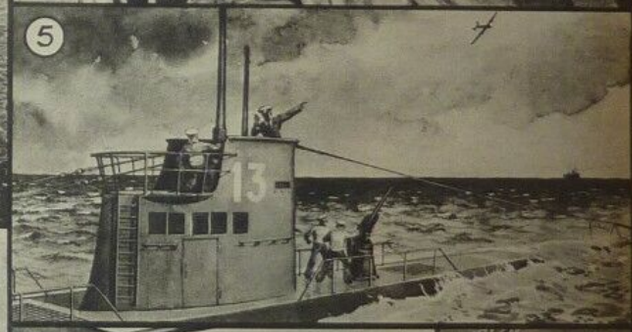
When a ship is sighted, as in Fig. 4, the pilot takes over again and wireless communication is held with the ship, and shortly after an enemy submarine is sighted. This is the bomb aimer's chance of a lifetime. We show him lying at full length in the nose of the aircraft, using his intricate bomb sight and the forefinger of his right hand pressing a bomb switch. In Fig. 7 a bomb is seen leaving the plane. When released from its holder (A) it falls on the spring trapdoors (controlled on the principle of a spectacle case), and forces its way through. The springs (B) bring the doors back into position. In Fig. 8 we show how the bomb is released before the objective is reached because the forward speed of the aircraft causes the bomb to fall as shown by the curved line. The straight line is to give some idea of the true angle of the bomb's fall.

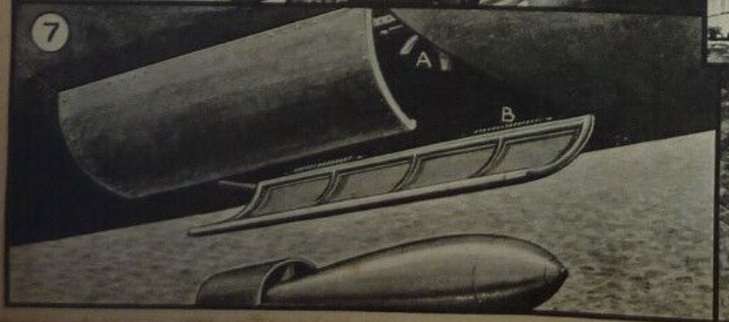
On the return journey from a security patrol, a number of pigeons are generally released for training purposes. They would be used in emergencies, such as a crash or a wireless breakdown.

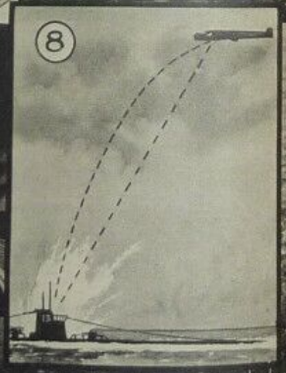


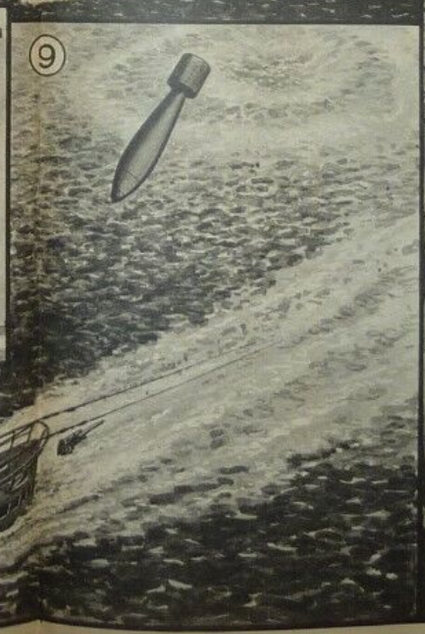




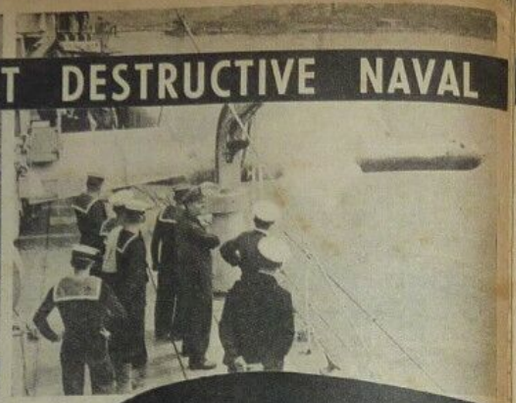


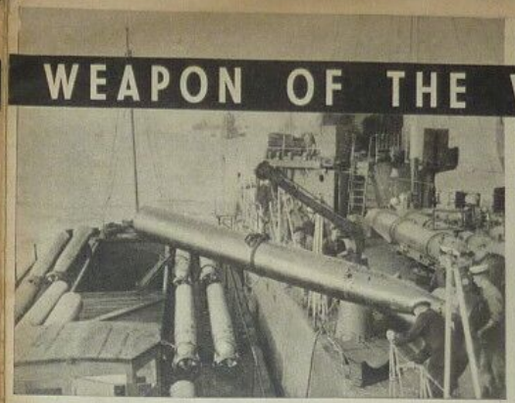


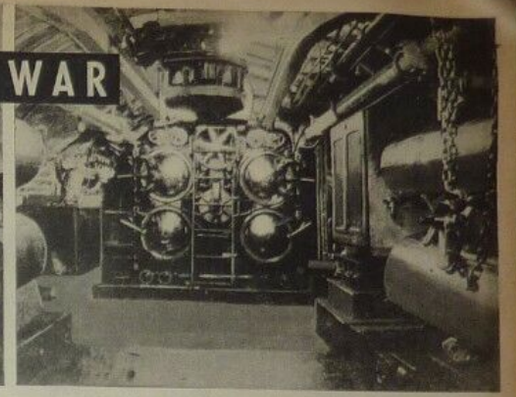




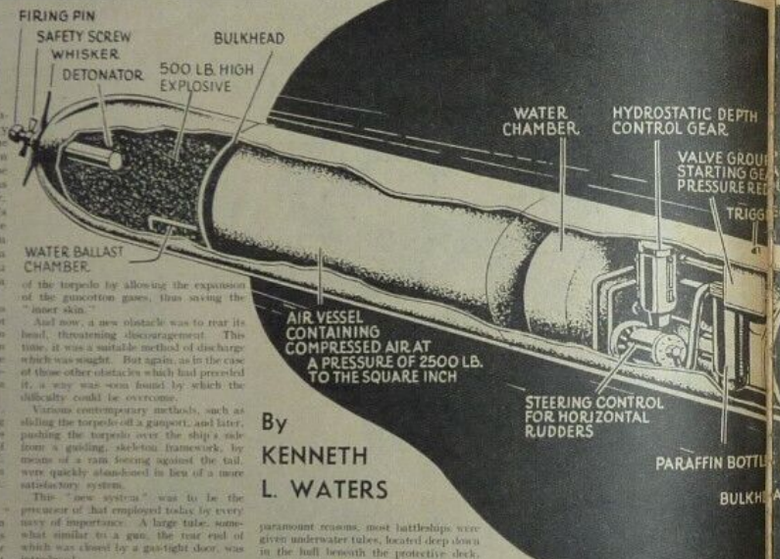
MOST DESTRUCTIVE NAVAL WEAPON OF THE WAR







From Robert Fulton's simple invention has developed this highly complex instrument of modern naval warfare



By KENNETH L. WATERS

NAVAL artillery had so improved in range, accuracy and effect by the time of the Napoleonic wars that when emerging from a battle the ships of the victor were often nearly as badly damaged as those of his adversary. This state of affairs turned men's thoughts towards the discovery of some method of protecting their ships from the murderous enemy fire, and as a result experiments were begun in 1842 by fitting iron plates to the sides of a wooden ship.

This was the launching of the "vicious circle," a never-ending, three-way contest between the factors gun power, protection (armour) and speed. First one and then another of these factors would gain the upper hand, until it had become a "touch-and-go" affair with no one able to hold a permanent superiority over the others.

Then came the torpedo! Not overnight, but only after long years of heart-breaking struggles and failures. Eighty-six years were to pass before this new instrument of naval warfare was to fully vindicate itself. Eighty-six years during which many men were to die leaving their dreams unrealized, while others stepped into their place.

It was in 1805 that Robert Fulton demonstrated to a sceptical public, his method for destroying ships while at anchor by exploding a charge of powder against the hull under water. Such was the germination of the torpedo.

Throughout the last quarter of the nineteenth century, this weapon dominated the field, although prior to the World War torpedo attacks were relatively few. In 1890, a Chilian warship was sunk while at anchor by one torpedo. Again, in 1894, a Brazilian warship was sunk by a single torpedo. Then in 1895, during the Sino-Japanese conflict, four Chinese ships were sunk in the harbour of Weihaiwei.

These sinkings, as might be expected, gave warning of the growing power of this new weapon. Wherefore, naval designers calling all their skill into play, met this danger by arranging a system of fabrication for ship's bottoms that is, reinforced cellular decisions between the double bottoms. Also, soon after the turn of the century, the "bulge" or "blister" idea was being thought of (in its early stages, of course). This was a sort of cannon affixed to a ship's hull immediately below the waterline where a torpedo would strike. It was merely a heavily braced air space which served to reduce the explosive force of the torpedo by allowing the expansion of the guncotton gases, thus saving the "inner skin."

And now, a new obstacle was to rear its head, threatening discouragement. This time, it was a suitable method of discharge which was sought. But again, as in the case of those other obstacles which had preceded it, a way was soon found by which the difficulty could be overcome.

Various contemporary methods, such as sliding the torpedo off a gunport, and later, pushing the torpedo over the ship's side from a guiding, skeleton framework, by means of a ram, soon proved to be unsatisfactory systems.

This "new system" was to be the precursor of that employed today by every navy of importance. A large tube, somewhat similar to a gun, the rear end of which was closed by a gas-tight door, was introduced.

Of late years the above water deck tubes seemed to have gained at the expense of their submerged brothers, since even cruisers of thirty years ago had underwater tubes.

With such a system of mounting, a much wider radius of aim is attained, which, of course, greatly multiplies the efficiency of the tubes. And with the continuous improvement of the torpedo itself little difficulty was experienced in discharging it from the increased height of the deck, destroyers of these days having extremely low quarter-decks.

And yet it must not be thought that the deck-tube mountings are without their disadvantages for this is not true. In fact there exists a constant danger of an enemy shell striking the tubes and detonating the torpedoes, thus destroying their own ship. Then, too, in the case of high freeboard cruisers and capital ships, some trouble has been experienced in launching the torpedoes from deck tubes due to the greater height from which they must drop before starting their under-water run. With these as the paramount reasons, most battleships were given underwater tubes, located deep down in the hull beneath the protective deck, where they would be fairly secure from enemy fire.

Immediately, however, as if to thwart this aim, new obstacles appeared. The rush of water past the ship in motion acts to throw the torpedo's head off to one side as it emerges from the tube, in that manner diverting it from its true course, if not actually damaging the torpedo itself. Something had to be devised which would shield the torpedo from this force until it could completely clear the tube or "orifice." For that purpose, a shield bar was fastened to the forward side of underwater tubes. Special brackets working in grooves along the shield bar are hooked by the torpedo as it emerges and run the length of the bar with it, or in other words until it is free of the tube, then disengaging.

Records clearly indicate World War inference on the present-day fleets, for in that terrible conflict the destroyer proved itself beyond a doubt to be the submarine's worst enemy and consequently the greatest hindrance to the free and unrestrained use of submarine, the two principal users of the torpedo, has resulted in somewhat of a stalemate which has to a large extent checked the torpedo's power.

In addition to this serious setback, however, still another blow has been administered to the effectiveness of the torpedo in the form of highly-perfected systems of hull construction which tend to minimize the effect of the explosive forces.

Should this, one might then ask, be taken to indicate a beginning of the end for submarines? Any naval officer or other authority would, I am sure, reply to this question in the negative! Definitely so, in fact, for it should be realised that in all phases of warfare, a continuous struggle is evident between the forces of offence and defence, with first one and then the other gaining the advantage.

Applying this to our subject, we see a comparatively new weapon, the submarine, using a new type of projectile, the torpedo, coming upon the stage of the Great War and in a terrible campaign of destruction, nearly succeeding in clearing the seas of all opposing shipping. The offence was in the ascendancy!

Then came the many countering weapons and systems. The ruthless submarine campaign was blocked. More and more instruments and ideas for the sinking of submarines were produced and were showing marvellous results when the war ended. The sun of the defence had risen!

In the twenty years since the Armistice offensive and defensive measures have progressed apace, the development of a third weapon, the aeroplane, giving the defensive the edge which it now holds, chiefly by way of its great powers of observation. But this is by no means an assurance that such will always be the case. Past history tends to indicate that it will not. The submarine and the torpedo have invariably been linked together, mutually dependent, one upon the other. In 1914 to 1918 it was the torpedo which was mostly dependent upon the submarine for successful use and accomplishment. Now, however, the tables have turned and it is to the torpedo that the submarine must look to uphold the power of the undersea boat.

Enlarging upon this theme, it may be pointed out that a number of modernizing improvements upon the torpedoes themselves await execution. Should these advancements be successfully completed, the submarine (and therefore the offensive) will be placed well along the road to supremacy once again.

A discussion of the future of the torpedo thus having been embarked upon, a résumé of these needed improvements becomes appropriate. First, and perhaps primary in importance is the necessity for eliminating the tell-tale bubble track created by the discharge of compressed air from the torpedo as it travels along. In the past, this "track," which resembles a white streak in the water, has often given warning of a torpedo's approach in time for the helmsman of an attacked vessel to turn and avoid being struck. Any invention which could successfully eliminate this difficulty would certainly constitute a great improvement.

Secondly, if torpedo attacks are to be made upon modern, fast vessels, with even reasonable chances of success, the speed of torpedoes over long distances must be increased by a considerable degree. Admittedly, this is easier said than done, but it is not impossible. For years engineers worked on this problem and succeeded in raising the speed from a bare six miles per hour in the first Whitehead to some fifteen to twenty knots (depending upon the range) in later models.

This was increased to some thirty to thirty-five knots in the World War torpedoes, and has since been still further improved until at present they are capable of making fifty knots at ranges up to approximately 4,600 yards, which is of itself a considerable achievement. Turning to facts as shown by figures, the situation takes on quite a different appearance.

Picture, for instance, a submarine firing a torpedo at a modern cruiser. The submarine commander has sighted the oncoming warship and manœuvred his craft into position for an attack. The distance over which the torpedo will have to run is approximately two miles, and the cruiser is steaming at thirty-five knots. Reducing this to a basis for comparison, finds the surface ship covering 3,346 ft. per minute, while the torpedo in the same period of time travels 5,068.8 feet—considerably more than the cruiser. It will thus take approximately 2.08 minutes for the torpedo to traverse the two miles to the ship, and in that same elapse of time the cruiser will have gone no less than 7,376.5 feet!

All of which simply points to the key factor—accuracy. The high cost of torpedoes and the limited numbers carried by submarines prohibit their use for random shots. Accuracy must be maintained, and this cannot very well be done with a submarine commander forced to aim over 7,000 feet ahead of his target to allow the torpedo time to cross the intervening space, thus giving the cruiser adequate time to sight and avoid it by sheering off. Also, were the cruiser to be at a greater distance, say three miles, the speed of the torpedo would be drastically decreased.

What, then, is to be done? Two alternatives present themselves. Either the speed of torpedoes over long distances must be substantially increased, or the submarine will be forced to run in close to its target—a truly perilous undertaking, which to a large extent, was responsible for the relative paucity of submarine attacks on the British Grand Fleet during the war.

And, last, but by no means least, is the enigma of torpedo versus bulge protection. Like aircraft bombs, torpedoes have no striking energy except that which they accumulate from the natural forces of momentus during the course of their flight or run. For this reason it has been necessary to fit them with warheads that explode upon contact. And here is where the bulges fitted to modern battleships and cruisers, present the third major impediment to successful torpedo attacks on warships.

Like a barrier, these bulges stand between the torpedo and the vital "inner skin" of the ship, and until some system of torpedo construction can be devised which will provide for the penetration of these bulges by a torpedo before exploding, a submarine can hope to do no more than cripple a first-class warship, although there is a possibility of doing so, as demonstrated in the case of the *Royal Oak*.

Some such thoughts as these must have been entertained at various times in the past, for history deals in quite some detail with the invention of Commander Cleland Davis, who so sought to concentrate the powers of attack that only a fraction of the force would be dissipated. Knowing that the tendency of previous torpedoes had been to waste a large portion of their destructive force by exploding upon the—or in other words, following the line of least resistance—Davis hit upon the idea of installing an eight-inch gun within his torpedo. The principal upon which this torpedo operated was comparatively simple and quite logical.

A small wheel on the torpedo's nose and a trigging rod were so arranged as to automatically "prime" the weapon for discharge upon contact. Upon colliding with an obstruction, this trigging rod is driven backwards, engaging a trigger which first compresses and then releases the spring of the firing pin. This fires the gun, point-blank against the bulge plating, which is of course penetrated by the eight-inch shell, as is the inner skin also, in most cases. The shell's bursting charge of thirty-five to forty pounds of guncotton was then detonated inside the ship by a delayed action fuse, timed to a hundredth of a second. The shell had an initial velocity of 1,000 ft. per second—sufficient for the penetration of four to five inches of armour plating.

(Condensed from "Our Navy," U.S.A.)

SIGNS OF THE ZODIAC

Aries, the Ram

Taurus, the Bull

Gemini, the Twins

Cancer, the Crab

Leo, the Lion

Virgo, the Virgin

"ALL STAR" DRAMA OF THE SKIES

THE BLACKOUT HAS BROUGHT A NEW WARTIME HOBBY TO MANY

by Harry M. DAVIS

FOR millenniums the planetary performers have been seen in various groupings, as morning or evening stars, against the background of the starry vault. For millenniums men have been trying to explain these goings on; and the explanations of old still survive today both in our scientific terminology and our superstitions.

Sometimes it is useful to erase momentarily from our minds the things we learned in school—that the earth is round, that it rotates each day on its own axis, that it also revolves around the sun once a year in the same way that the other planets do—and revert to the picture men had before the time of Copernicus and Galileo. It was the obvious picture derived from the senses—the earth, hub of the universe, stood still while sun, stars and planets whirled around it.

Stargazers of Babylon and Greece did not know the real difference in structure, temperature and distance between a planet and a star, but they did notice a striking difference in behaviour. The stars, in contrast to the planets, seemed to revolve around the earth as a single unit. They might have been pinholes punctured in a huge shell with light shining through from the outside. This "celestial sphere" seemed to revolve around the earth once a day. It also executed an annual manoeuvre which brought different constellations into view at different hours of the night as the seasons progressed. Thus one could mark the coming of winter or the time to sow seeds in spring by the position of such bright groups as Orion and the Big Dipper.

That made everything fairly simple—except for those celestial anarchists, the planets. Against the celestial sphere they were seen in ever-changing positions. The very name "planet" tells the story; it is the Greek for "wanderer." But the planets did not wander everywhere. They always were seen in a definite section of the celestial sphere. It was in the same region that the sun was seen to rise and set, the same in which the moon appeared in all her phases. This section of the sky astrologers called the zodiac, meaning literally "animals," because of the animal shapes which they thought some of the constellations took.

If the sky as a whole is the theatre, the zodiacal region in particular is the backdrop for the regular seasonal motion of the sun, for the monthly changes of the moon, and for the peculiar wanderings of the planets. It is no wonder that observers in all countries and all times have paid special attention to the zodiac—although actually it is made up of stars not different from those in other parts of the sky.

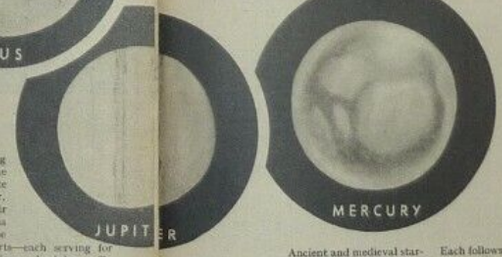
The zodiac may be pictured as a broad east-west highway of the heavens. Its position in the sky depends on what part of the earth the observer happens to be looking from, and on the season. The zodiac is an arch extending fairly high across the southern sky from the south-eastern horizon to the south-west. It is a multi-lane highway, thirty-two times as wide as the sun's apparent diameter, which means that Jupiter has plenty of room to pass Venus without eclipsing her.

The celebrated "signs of the zodiac" are nothing but celestial roadsigns to mark the wanderings of the planets. Since the sun itself moves along the centre-line of the zodiac in a complete circuit once a year, the Greeks and their predecessors of Asia Minor divided the zone into twelve parts—each serving for one month as the sun's own backdrop. To each part of "sign" was given a mythological name, derived partly from the season during which the sun traversed it, partly from the figures that ancient eyes discerned in the patterns of the constellations.

The signs were—and we still use these names—Aries, the Ram; Taurus, the Bull; Gemini, the Twins; Cancer, the Crab; Leo, the Lion; Virgo, the Virgin; Libra, the Balance; Scorpio, the Scorpion; Sagittarius, the Archer; Capricornus, the Goat; Aquarius, the Water-carrier, and Pisces, the Fishes. It really took a lot of imagination to conjure such figures out of the points of light in the sky. Except that the five-starred "V" of Taurus does suggest the horns of a bull, while Gemini's two stars of nearly equal magnitude could hardly have been called anything but twins, the modern eye finds it hard to project the zodiacal creatures on the backdrop.

The stars of this group are not, as a whole, very bright, a fact which, for the purposes of celestial drama, is all to the good. Like a well-designed stage setting the zodiacal stars make no attempt to outshine the chief actors—the temperamental planets.

Mars as seen from one of its satellites!



A PAGEANT OF THE HEAVENS—

"Nine planets and a million stars"

Ancient and medieval stargazers who called themselves astrologers attributed a special character to each sign of the zodiac and to each of the planets. Some were held to be sympathetic to each other; others, antagonistic. From the position of the sun and planets in the zodiac at a client's birth, astrologers offered to tell him under what planetary circumstances he could best sow grain, propose marriage or make war.

These superstitions have survived to this day. A recently published astrology book, for example, reports that Sagittarius governs the hips, causes falls from a horse, makes the character enigmatic, gives love of hunting, of science or art, energy, an ordered mind. The influence of Jupiter adds wisdom, honour, discrimination." Horoscopes are said to govern the decisions of certain highly placed European statesmen and certain highly paid Hollywood stars. Astrology, in fact, is becoming big twentieth century business, for this much can be predicted with certainty—a sucker is born under every sign of the zodiac.

In modern astronomy the mythological names of the zodiac are still used to label their regions of the sky and to serve as a frame of reference for charting the movements of the planets. But the explanation of these movements is given in terms of mechanics rather than myth. The law of gravitation—Newton derived it from a study of the planetary motions — makes it possible to figure out just why Jupiter or Venus should be at a given spot in the sky at a given time.

Against the background of the zodiac the planets may be seen in infinitely varied arrangements. Each follows an orbit determined by its own mass, speed and distance from the sun, and each is affected also by the gravitational pull of the other planets. The result is that the planetary line-up is never exactly the same repeated. Every evening brings a new configuration in astronomical history.

Some configurations are more interesting than others. For example, it is quite ordinary for one planet to take the role of evening star, one the morning star, while three others remain invisible because they are out in the daytime. If all five were morning stars no one but the milkman and a few starry-eyed enthusiasts would see them. When all five of the bright planets appear at once in the early evening, at the most convenient time for human observation, they provide the planetary show of a lifetime—a show that was seen recently.

Mercury, in many ways, resembles the moon. It is about the same size and, like moon. It is airless and arid—no life upon it is conceivable. Through telescopes, it appears to go through a cycle of phases from new to full. Circling closer to the sun than any other planet, Mercury is never more than two hours before or behind the sun in rising and setting. Because as an "evening star" it is often invisible in the twilight and as a "morning star" it is usually lost in the dawn, Mercury has been nicknamed the "elusive planet." It is said that Copernicus, who first proved that the planets revolve around the sun, never saw Mercury.

Jupiter, the next planet in line, is at the opposite extreme of size. Larger than all the other planets put together, it could easily hold 1,300 earths. It takes twelve years to get around the sun. With its following of eleven satellites, two of them discovered in 1938, this impressive planet represents a sort of miniature solar system. Indeed, it was only after Galileo demonstrated the Jovian satellite system with his first telescope that the world gave credence to the Copernican explanation of the solar system.

Venus is so bright that under favourable conditions, it can throw a shadow on a clear, moonless night. Because its orbit is closest to our own and it most nearly resembles the earth in size and length of "year," Venus is often called the earth's "twin sister." But in spite of its nearness, astronomers have been able to discover very little about conditions on Venus for it is modestly enveloped in a heavy layer of clouds.

Saturn through a telescope presents the most amazing sight of any object in the heavens—with a girdle of bright rings around its equator. Depending on its position, we see these rings now from above, now from below, sometimes edgewise.

Mars is the most provocative of the planets, for intensive observations have not precluded the possibility that life may exist there. Recent photographs confirm the existence of an intricate set of lines, called "canals," on the face of the red planet's otherwise smooth surface. Whether intelligent beings were responsible is anybody's guess. Dark areas which vary with the seasons strongly suggest the presence of vegetation.

(Condensed from the "New York Times Magazine")

SIGNS OF THE ZODIAC

Libra, the Balance

Scorpio, the Scorpion

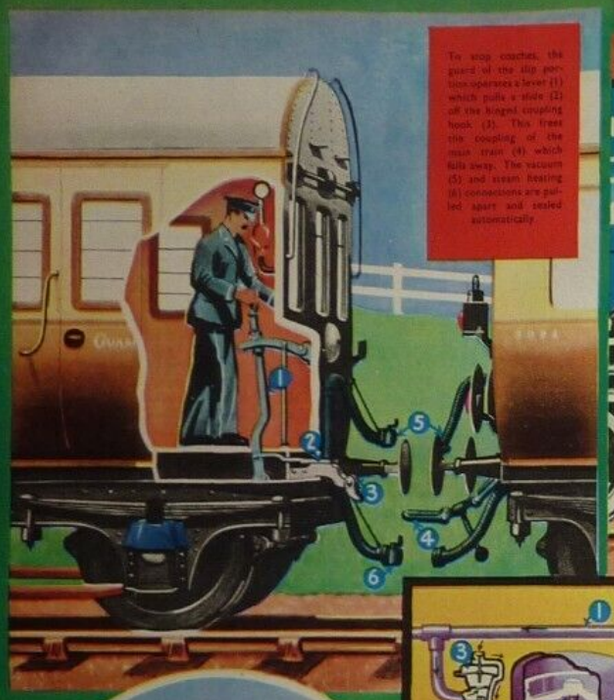
Sagittarius, the Archer

Capricornus, the Goat

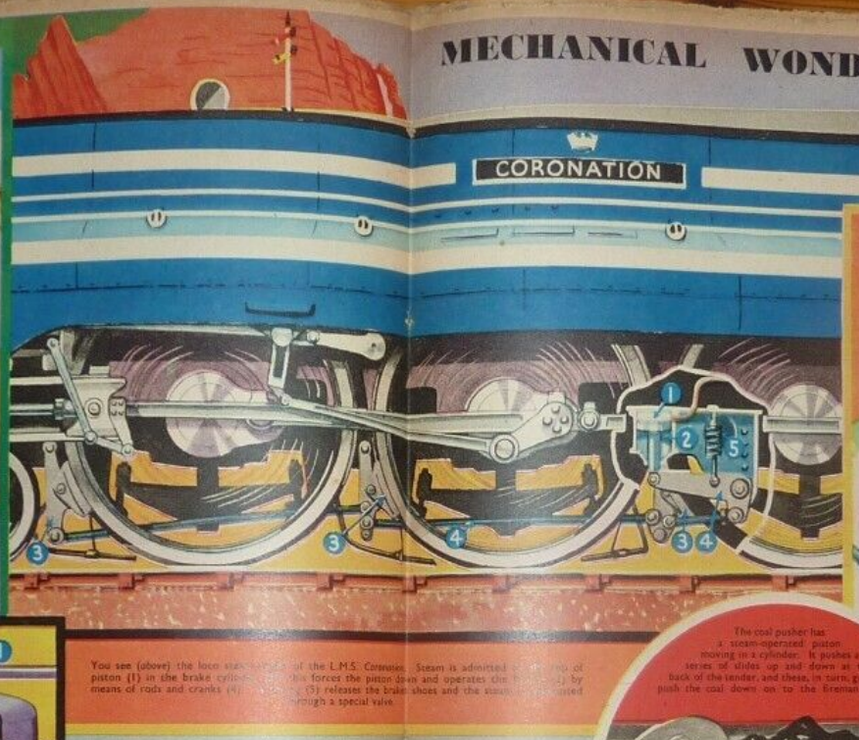
Aquarius, the Water-carrier

Pisces, the Fishes

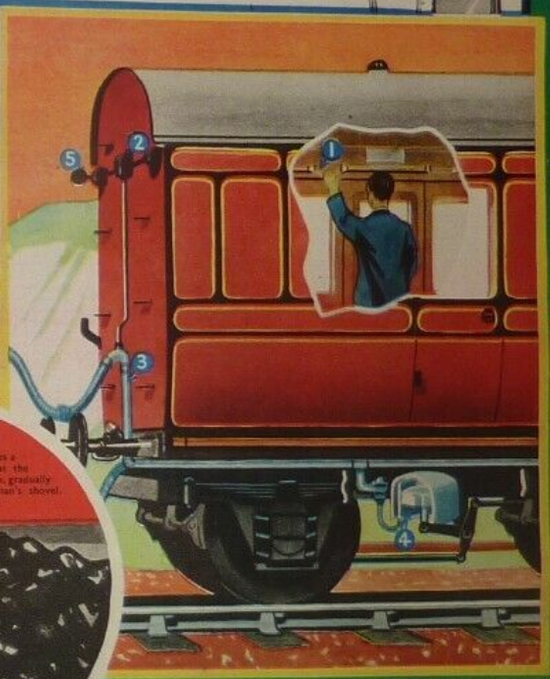
MECHANICAL WONDERS OF THE RAILWAY



To stop coaches, the guard of the slip portion operates a lever (1) which pulls a slide (2) off the hinged coupling hook (3). This frees the coupling of the main train (4) which pulls away. The vacuum (5) and steam heating (6) connections are pulled apart and sealed automatically.



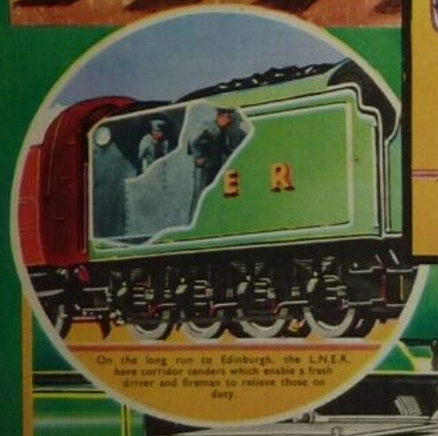
You see (above) the loco stage of the L.M.S. Coronation. Steam is admitted to one end of piston (1) in the brake cylinder. This forces the piston down and operates the brakes (2) by means of rods and cranks (3). A valve (5) releases the brake shoes and the steam is exhausted through a special valve.



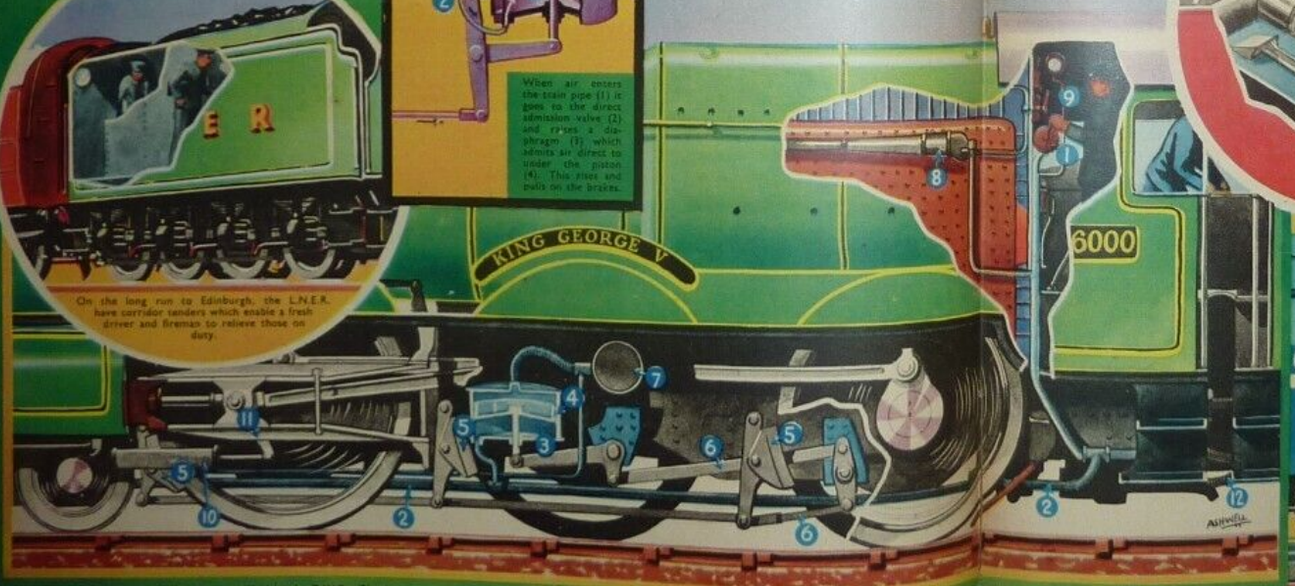
When the communication cord (1) is pulled it opens an air valve (2) at end of carriage and admits air to the train pipe (3) which operates the pistons (4) of the vacuum brake and so applies the brakes, as described elsewhere on this page. An arm (5) sticks out of the particular carriage to tell the guard where the cord has been pulled.

When air enters the train pipe (1) it goes to the direct admission valve (2) and raises a diaphragm (3) which admits air direct to under the piston (4). This rises and pulls on the brakes.

The coal pusher has a steam-operated piston moving in a cylinder. It pushes a series of slides up and down at the back of the tender, and these, in turn, gradually push the coal down on to the fireman's shovel.



On the long run to Edinburgh, the L.N.E.R. have corridor tenders which enable a fresh driver and fireman to relieve those on duty.



This is the vacuum brake system as worked by the G.W.R. The driver is applying the brakes by allowing air to enter the air valve (1). This passes to all the cylinders on the train through the train pipe (2). Here it is raising the piston (3) in the locomotive cylinder (4) and applying brakes (5) by means of rods and cranks (6). A reserve of vacuum is maintained in the vacuum reservoir (7). Air is exhausted from the train pipe when brakes are released by the steam air ejector (8) which is operated by steam valve (9). This maintains a vacuum again in the train pipe and the pistons of cylinder fall downwards. A vacuum pump (10) serves the same purpose when the engine is running. This is driven from the crosshead (11). Flexible couplings (12) allow the whole train pipe, allowing the pressure to be transmitted to every coach, thus assuring that the braking power will act upon the whole train.

The fireman on the Coronation Scot has lowered the scoop of the water pick-up (1) and while travelling at 60 m.p.h. 2,000 gallons of water are picked up in twenty seconds. A deflector (2) in front of the scoop directs the water right into the scoop mouth. This deflector goes up and down with the scoop. The water troughs are six inches deep and eighteen inches wide. An air vent (3) allows the displaced air to escape.

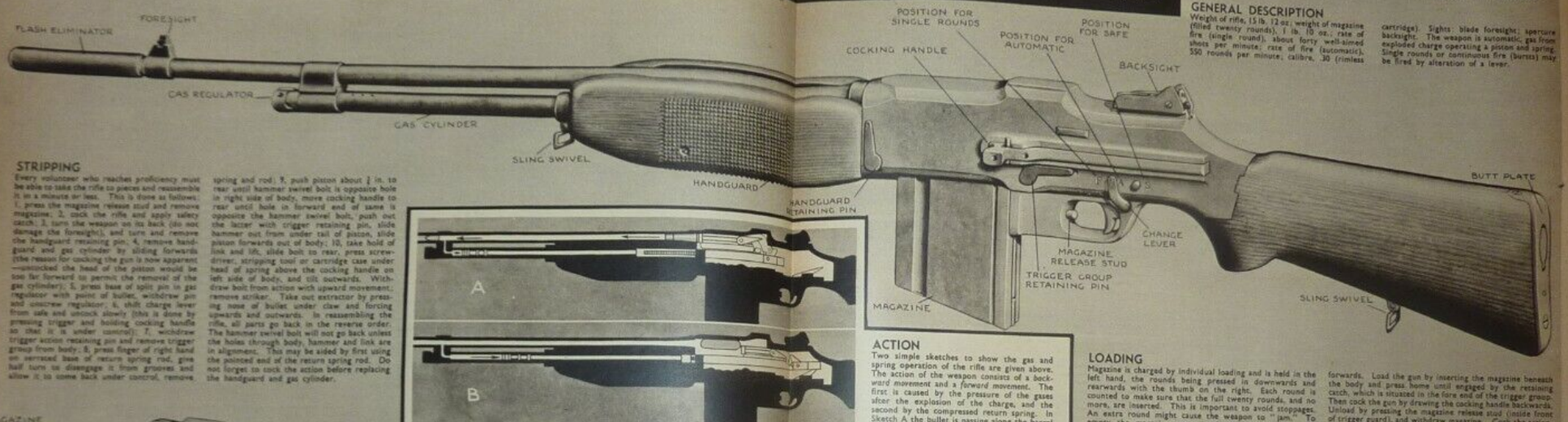
HOME GUARD TRAINING CHART

BROWNING AUTOMATIC RIFLE

Recently many sections of the Home Guard have been issued with a Browning automatic rifle for instructional purposes, and officers have been lecturing the enthusiasts on the use and care of the weapon. The sketches on these pages may help those of our readers who wish to make themselves more proficient.

GENERAL DESCRIPTION

Weight of rifle, 15 lb. 12 oz.; weight of magazine (filled twenty rounds), 1 lb. 10 oz.; rate of fire (single round), about forty well-aimed shots per minute; rate of fire (automatic), 550 rounds per minute; calibre, .30 (rimless cartridge). Sights: blade foresight; aperture backsight. The weapon is automatic, gas from exploded charge operating a piston and spring. Single rounds or continuous fire (bursts) may be fired by alteration of a lever.



STRIPPING

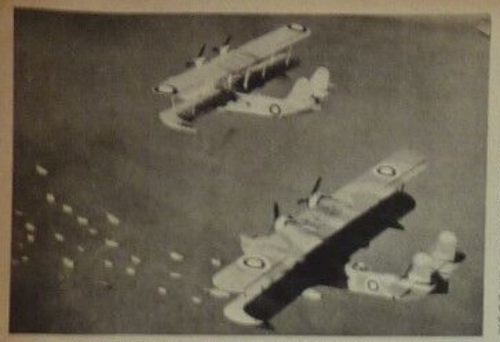
Every volunteer who reaches proficiency must be able to take the rifle to pieces and reassemble it in a minute or less. This is done as follows: 1, press the magazine release stud and remove magazine; 2, cock the rifle and apply safety catch; 3, turn the weapon on its back (do not damage the foresight), and turn and remove the handguard retaining pin; 4, remove handguard and gas cylinder by sliding forwards (the reason for cocking the gun is now apparent — uncocked the head of the piston would be too far forward to permit the removal of the gas cylinder); 5, press base of split pin in gas regulator with point of bullet, withdraw pin and unscrew regulator; 6, shift change lever from safe and uncock slowly (this is done by pressing trigger and holding cocking handle so that it is under control); 7, withdraw trigger action retaining pin and remove trigger group from body; 8, press finger of right hand on protruded base of return spring rod, give half turn to disengage it from grooves and allow it to come back under control, remove spring and rod; 9, push piston about ½ in. to rear until hammer swivel bolt is opposite hole in right side of body, move cocking handle to rear until hole in forward end of same is opposite the hammer swivel bolt, push out the latter with trigger retaining pin, slide hammer out from under tail of piston, slide piston forwards out of body; 10, take hold of link and lift, slide bolt to rear, press screwdriver, stripping tool or cartridge case under head of spring above the cocking handle on left side of body, and tilt outwards. Withdraw bolt from action with upward movement; remove striker. Take out extractor by pressing nose of bullet under claw and forcing upwards and outwards. In reassembling the rifle, all parts go back in the reverse order. The hammer swivel bolt will not go back unless the holes through body, hammer and link are in alignment. This may be aided by first using the pointed end of the return spring rod. Do not forget to cock the action before replacing the handguard and gas cylinder.

ACTION

Two simple sketches to show the gas and spring operation of the rifle are given above. The action of the weapon consists of a *backward movement* and a *forward movement*. The first is caused by the pressure of the gases after the explosion of the charge, and the second by the compressed return spring. In Sketch A the bullet is passing along the barrel propelled by the gases from the exploded cartridge. The pressure behind the bullet is considerable, and as soon as it passes the vent, the gases press through into the gas regulator, impinge on the head of the piston and force it backwards compressing the return spring. The empty cartridge case is carried back (held on the head of the bolt by the extractor), strikes the ejector and is thrown out through the ejector opening on the right-hand side. This is the *backward movement*. Sketch B illustrates the position before the beginning of the *forward movement* which follows. The compressed return spring forces the piston and bolt group forward. A cartridge pressed up by the magazine is forced into the breech. The hammer hits the head of the striker pin which detonates the round. After the bullet passes the gas vent the backward movement starts over again. The Browning automatic rifle is as a rule used for single shots, but can be used for rapid fire in bursts. The change lever regulates this. In its forward position single shots are obtained by pressing the trigger for each round. This must be done since the nose of the sear engages in the bent of the piston at the end of each backward movement, and retains it until the trigger is pressed.

LOADING

Magazine is charged by individual loading and is held in the left hand, the rounds being pressed in downwards and rearwards with the thumb on the right. Each round is counted to make sure that the full twenty rounds, and no more, are inserted. This is important to avoid stoppages. An extra round might cause the weapon to "jam." To empty the magazine, press each round downward and forwards. Load the gun by inserting the magazine beneath the body and press home until engaged by the retaining catch, which is situated in the fore end of the trigger group-more, are inserted. This is important to avoid stoppages. An extra round might cause the weapon to "jam." To empty the magazine, press each round downward and forwards. Load the gun by inserting the magazine beneath the body and press home until engaged by the retaining catch, which is situated in the fore end of the trigger group-more



A comparatively new branch of the R.A.F., Coastal Command now co-operates with the Navy in the protection of merchant shipping. It has recently been announced that these watch-dogs of the sea are to play an even bigger part in the war against the Nazis by combating the U-boat menace in the Atlantic.

U-BOAT THREAT

FRENCH BASES HAVE MADE NAZI SUBMARINE MENACE A BIGGER PROBLEM FOR THE NAVY

Cherbourg became available to them—potential bases to which our bombers gave due attention long ago. To the west are St. Malo and St. Brieuc, the former with a good harbour on the small scale and the River Rance which might be used for a U-boat sanctuary. On the west coast of Brittany are Brest, the former French naval base, and the port of Lorient, which has been so much in the news of late owing to the R.A.F.'s repeated attacks.

To the south, also on the Atlantic seaboard, are La Rochelle, facing the notorious Ile de Re where the French used to keep the convicts before sending them overseas to Devil's Island, and Bordeaux, about sixty miles up the estuary of the Gironde River from Biscay Bay.

U-boats have been taking a heavy toll, partly because they can slip out directly into the wide ocean avoiding former naval traps, and partly because we have insufficient craft of the right type to hunt them and to escort the cargo-carrying convoys.

"Grin and bear it" is not the kind of slogan for this sort of thing. We are fighting back, and may take good heart and courage that we shall weather this new menace to our sea-borne commerce. The Secretary of the Ministry of Shipping has stoutly affirmed that we shall defeat the submarine threat, and we may well be inspired by recalling that amazingly brilliant naval feat of the last war—the Zeebrugge Raid—which bolted the door on the U-boats' most useful lair.

It has been affirmed that no less than 6,000,000 tons of shipping were sunk in 1917, and the result of the war hung in the balance on account of this heavy loss. Aerial bombing was in its infancy and it was impossible to destroy these undersea pirates in their lases, and the various offensive measures adopted when they emerged, failed to stop their incessant attacks.

So, it will be recalled, a daring project was conceived for bottling them in the Zeebrugge-Bruges canal—in fact, the Royal Navy set out, not for the first time in its glorious history, to achieve "the impossible."

Consider what the British raiders were up against. The harbour at Zeebrugge was protected by a mole half a mile long, consisting of a stone jetty, an open steel-way and a huge concrete breakwater. German artillery, machine guns and searchlights were mounted along its length, and it was garrisoned by 1,000 troops. Along that part of the Belgian coast were 225 other guns, some of extremely heavy calibre. The entrance to the canal was guarded by patrol craft, anti-submarine nets and a vast number of mines.

One element was essential for a successful raid—surprise. And it is a fact, strange in itself, that this was achieved despite the point that it took two months to prepare the plan and the ships detailed for the attack, and for the intensive training of the gallant naval and marine volunteers and hand-picked men from the fleet. Weather and sea conditions had to be favourable—the tide high, the sea moderate, the wind blowing towards the Belgian coast, and no fog or rain.

After many disappointments, an amazing armada set out on April 22, 1918, the eve of St. George's Day, under the command of Vice-Admiral Sir Roger Keyes. The mole was stormed by bluejackets and marines, and terrific fighting ensued; a submarine loaded with explosives blew herself up and shattered the steel span to prevent German reinforcements reaching the breakwater, and many enemy cyclist troops hurtled into the sea.

Under terrible gunfire, blockships passed through the harbour which was ablaze by the devil's firework display, and were sunk in the dredged channel of the canal. British heroism persisted in the retreat, but 616 brave men were left to forfeit for a feat unparalleled for superb strategy combined with sheer audacity.

By the famous Zeebrugge Raid, no less than twenty three German torpedo boats and thirteen submarines were bottled up "for the duration." That canal was finished as a U-boat lair, and the successful blockade had far-reaching mutal effects.

Once again Zeebrugge has been blocked by the Royal Navy, on May 26, 1940, to be precise. In the face of severe enemy air attack, two blockships filled with cement were manoeuvred into position within the harbour and sunk there, and the canal lock was destroyed by explosives as were also stores of fuel. But even if the port is re-opened, it has not the same strategic value as formerly owing to the more useful bases further west.

The Atlantic base of Lorient has become the Zeebrugge of the present war, but with geographical advantages to the Germans. It is a Breton port of over 50,000 inhabitants, and was founded three centuries ago by the Company of India, from which it derived its earlier name of L'Orient—The East.

In modern times, the French developed it for naval purposes, and the Germans found ready-made quays, dry-docks, shipbuilding yards and an arsenal. There is an estuary of four miles leading direct to the open Atlantic, a deep-water channel where U-boats can lurk snugly as they did for so long in the Zeebrugge-Bruges canal.

In the joyous days of peace, Lorient had all the colour of a French naval port combined with that of a picturesque Breton market town and fishery centre. Artists used to go there to paint the peasants in their old-world garb, the women in lace head-dress, and fishermen wearing terra-cotta-coloured jeans.

At the beginning of the war, Germany had forty-three submarines in commission and several more on the stocks. Her Axis partner, Italy, had a grand total of one hundred and five, including eight large ocean-going submarines and six specially constructed for mine laying. No doubt feverish building construction has been going on, but it is impossible to know how many are available now for use under the stern conditions of Atlantic patrol.

There are three ways by which the U-boats may operate from Lorient and other bases that lead direct to the wide ocean. One is for a submarine to make for that area of sea, south-west of Ireland, where the trade routes converge towards the ports of unloading. Here the "sharks" may find prey, but it runs a greater risk of drawing the hunters on its track.

Another method is to patrol far out on the great ocean wastes in the hope of seeing the smoke of a convoy or lone ship. The third means is to secure information from agents in the pay of Germany or from aerial patrols as to the sailing time and route being used by cargo carriers. This may be effective, and is a reason for the notices displayed everywhere in Britain warning the public against talk that may possibly help the enemy.

The new Atlantic bases have become infested by U-boats, some of which have put in there instead of returning dangerously to their original lairs to overhaul. Others are building. Some may possibly be constructed in German, Dutch and Belgian yards and taken in sections by rail to be assembled.

This method was adopted successfully by the Germans in the last war, when they used the Hoboken yards near Antwerp for building submarines for transference piecemeal by train to Bruges, where the final work of assemble was done on the canal.

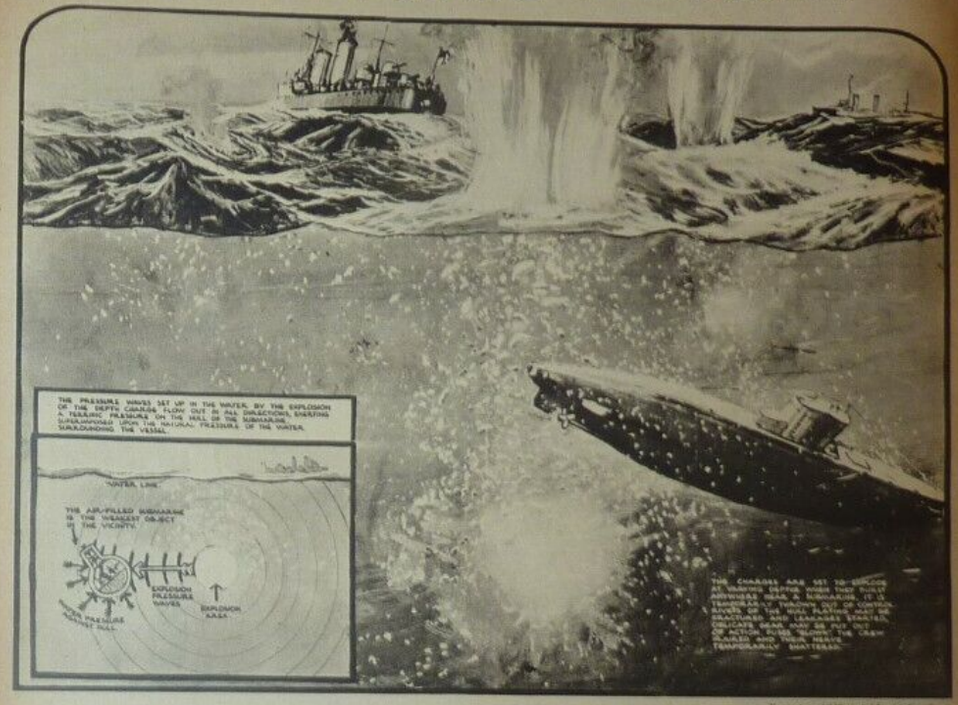
Whether, however, Lorient can ever be blockaded successfully like the Zeebrugge base, remains for the future to show. But the Royal Navy and the Royal Air Force can be relied on to give the matter their most earnest attention.

With the collapse of France, Germany was quick to assure herself of access to the Atlantic coast ports and naval bases of her new victim. The exact location of Lorient, the submarine base regarded as the Zeebrugge of this war shows its easy access to Atlantic patrolling U-boats.

[Below:] A pre-war review of Nazi U-boats at Kiel when the German Navy wanted to impress Hungary's Admiral Horthy with the invincibility of the National Socialist war machine. These submarines, no doubt, contributed to recent Hungarian exactions to the Axis and the link-up with totalitarian policy.

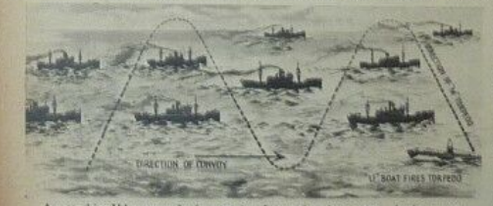
IN THE ATLANTIC

By W. E. STANTON-HOPE



By courtesy of "Illustrated London News."

Diagram showing the effect of a depth charge on undersea craft. Anywhere near at hand to the explosion rivets may be sprung so that leakages occur, and the delicate instruments on board may be thrown right out of gear. Hunting destroyers patrol in line formation abreast of each other, and by the use of modern listening and other devices are able to plot a spot on the ocean where suspicious noises made by U-boats are loudest, and converge upon it.



An attacking U-boat may fire its torpedoes from quite a long range. As the convoy steams past, the lurking submarine has many opportunities of hitting a target, unless adequate protective force is available to hunt it.

In the Zeebrugge Raid, no less than thirteen German torpedo boats and thirteen submarines were bottled up "for the duration." That canal was finished as a U-boat lair, and the successful blockade had far-reaching mutal effects.

Once again Zeebrugge has been blocked by the Royal Navy, on May 26, 1940, to be precise. In the face of severe enemy air attack, two blockships filled with cement were manoeuvred into position within the harbour and sunk there, and the canal lock was destroyed by explosives as were also stores of fuel. But even if the port is re-opened, it has not the same strategic value as formerly owing to the more useful bases further west.

The Atlantic base of Lorient has become

TANKS Light tanks in the Western Desert which played a big part in the recent rapid advance. This mechanized cavalry was used to penetrate the Italian positions, and for mopping up.

The "ARMY OF THE NILE" ATTACKS

COMMANDER Commander-in-Chief of the British Forces in the Near East, Sir Archibald Wavell. By taking the initiative against Graziani he has badly upset the Duce's plans of Egyptian domination.

AFTER months of idleness and boredom, British forces of the Middle East Command have made a successful thrust into the Western Desert. The grand-scale operations carried out by the Army, Navy and Air Force in December was the first real offensive in which British fighting men have taken part during the war.

Despite the need to send aid to the Greeks when Italy attacked, our strategy was worked out carefully in preparation for the day when we could strike heavy blows at the very junior Axis partner.

Since the Italian advance shortly after entering the war all was quiet in the desert, save for occasional patrol activities. After the first impetus of this advance, Graziani's soldiers had remained unexpectedly inactive. The heralded attack on Egypt had failed to materialize. The lightning stroke that would take the little dictator a step nearer Suez hung fire.

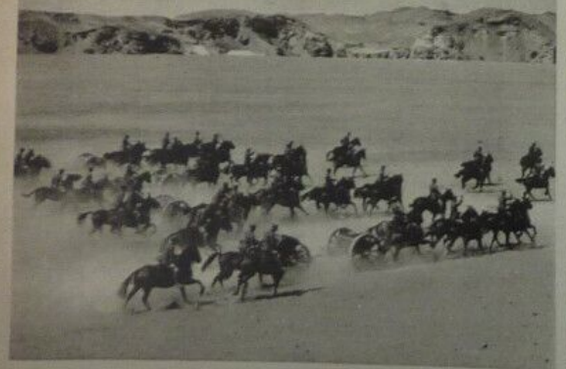
As the first grey streaks of light flitted across the desert sky at dawn on a Monday in early December, British troops swooped on an Italian outpost, taking over 500 prisoners. The fight was on! During the day, and under a full moon, the British troops continued to use the opportunity given to them by direct contact with the Italians.

With mobile units of light tanks, Bren-carriers and all the other impedimenta of a modern army no longer relying on the staying power of the camel, our troops swept into Sidi Barrani. In three days this tiny town, which had become the hub of the Italian Army in Egypt, had fallen. Thousands of prisoners fell into British hands, including five generals. The full extent of the effect of these operations on the future course of the war in general, and on Italy's prospects in particular, cannot be estimated at the early stage of writing. But the whole operation has been successful from our point of view, and has displayed to the world the fact that British military genius didn't die with Wellington.

Soldiers, sailors and airmen all played their parts in this first attack on Italian positions. Whilst mobile forces stole unexpectedly on the Fascist forts, pilots of the R.A.F. kept up a ceaseless bombardment of every enemy airfield operating over this part of the front. At the same time the navy followed up its great work at Taranto by shelling coast roads. Co-ordination was the secret of success.

B.H.

INFANTRY Picked troops have been "standing at ease" in the desert for the past few months. Now their opportunity to take a "crack" at the Italians has come, and these machine gunners know exactly the way to wage desert warfare in the most telling form.



ARTILLERY During the lull since the first Italian advance, when they first entered the war, there has been little activity save that of patrols and occasional shelling by the artillery. Although this picture was taken during manœuvres, the Royal Horse Artillery is no doubt playing its part in the present operations.

AIR FORCE Whilst the land forces stole unexpectedly on the enemy, the R.A.F. were playing their part, bombing all aerodromes in the hands of the Italians which could send aircraft to the scene of the fighting. In the first day or so of the battle, twenty-two Italian planes were shot down over the desert and many badly damaged.

NIGHT TRAINER FOR R.A.F.

The General Aircraft "Owlet" is the latest addition to Britain's training planes. The increased efficiency of this plane will result in a speed-up in pilot output

By BRYAN S. McCANN

IN these times when the cry is for "More planes and more men for the R.A.F." it is only natural that a new type of aircraft should cause a considerable stir among the controllers of the air arm as well as among those who stand to guard its welfare. This is the case with the General Aircraft "Owlet" day and night trainer which was flown for the first time recently.

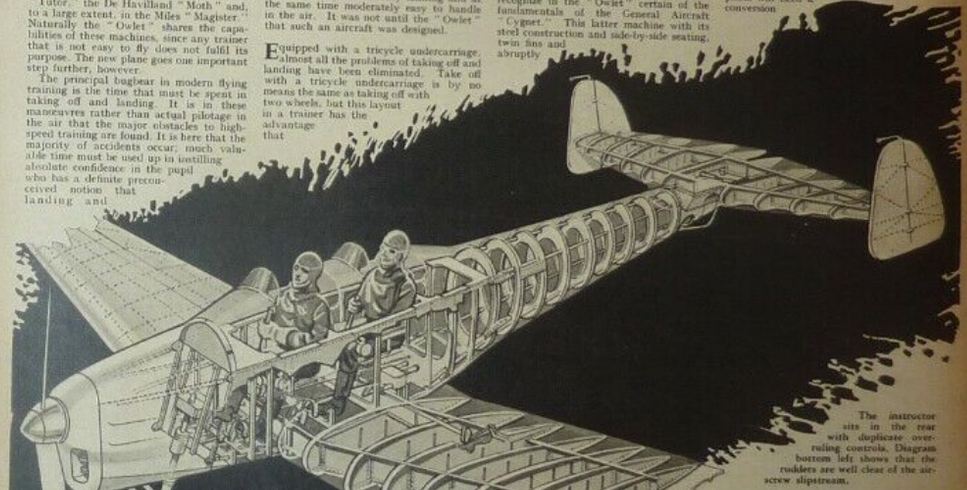
It would be grossly inaccurate to say that a stir had been caused about this machine merely because it is of new design. The "Owlet" has much more to commend it than scarcely dry dope on its wings. The design embodies many of those features which are essential to trainer efficiency, but which for too long have been ignored.

The first essential of a good training aircraft is easy flying. This quality has been long available in what are regarded as the "uncrashable" trainers, the Avro "Tutor," the De Havilland "Moth" and, to a large extent, in the Miles "Magister." Naturally the "Owlet" shares the capabilities of these machines, since any trainer that is not easy to fly does not fulfil its purpose. The new plane goes one important step further, however.

The principal bugbear in modern flying training is the time that must be spent in taking off and landing. It is in these manœuvres rather than actual pilotage in the air that the major obstacles to high-speed training are found. It is here that the majority of accidents occur; much valuable time must be used up in instilling absolute confidence in the pupil who has a definite preconceived notion that landing and taking off are the most difficult things in the world. All of these faults must be attributed to lack of foresight on the part of trainer designers.

Knowing that take off and landings present these problems, the training command of the Air Ministry should have concentrated certain of its efforts to eliminate the delays caused thereby. The obvious way to set about this was to build an aircraft whose principal characteristic was easy take off and easy landing and at the same time moderately easy to handle in the air. It was not until the "Owlet" that such an aircraft was designed.

Equipped with a tricycle undercarriage, almost all the problems of taking off and landing have been eliminated. Take off with a tricycle undercarriage is by no means the same as taking off with two wheels, but this layout in a trainer has the advantage that



The instructor sits in the rear with duplicate over-ruling controls. Diagram bottom left shows that the rudders are well clear of the air-screw slipstream.

the two-wheel take off can be learnt at a later stage in the training after the pupil has gained that confidence which makes for good flying.

The normal take off with an aircraft equipped with a two-wheel undercarriage involves a short period in which the pilot must make up his mind whether he has sufficient speed to manipulate his controls and endeavour to leave the ground; this varying with prevailing conditions. To an experienced flyer the thrill of the take off never dies, there is always that perhaps minute element of uncertainty about the manœuvre; it can be readily appreciated therefore that to the novice this part of flying involves sticky hands and much collar loosening.

It is safe to say, however, that a tricycle undercarriage almost "takes off by itself," and as a trainer that is where the "Owlet" scores.

This question of take off is most important since it is to this quality that the principal claim to being a day and night trainer lies. The day and night business merely means that the take off and landing qualities of the machine are considered so elementary that training can be proceeded with under the frequently adverse conditions of night.

At first glance, those who know the layout of various private aircraft will recognize in the "Owlet" certain of the fundamentals of the General Aircraft "Cygnet." This latter machine with its steel construction and side-by-side seating, twin fins and tapering fuselage has achieved a definite distinction in many parts of the world.

It is Britain's only all-metal light civil aeroplane and although not originally designed with a tricycle undercarriage this was later fitted as standard. It is well that an owl's egg became mixed with those of the swan, since the "Owlet" does much to credit its parent, adopting many of the latter's characteristics.

The principal difference is in the accommodation, the "Cygnet" has side-by-side seating for two, while the "Owlet" has two seats arranged in tandem formation.

In construction, however, there are many features that are common to both. This is a wise move which General Aircraft probably learned from Hawker Aircraft, and other concerns, who converted existing machines to varying requirements. Thus the tools already installed for production of the "Cygnet" will equally well serve for the "Owlet."

Noticeable features about the new trainer are the pronounced dihedral of the wings and the twin fins which are set outside the slipstream. The positioning of the fins thus makes for better and easier control.

In demonstration flights, Mr. Charles Hughesden gave an astonishing display of the aircraft's manœuvrability, including aerobatics and banking turns very near the ground. With such a pronounced dihedral and the gusty wind which was blowing all the time, it was surprising that when the plane came in to land it showed no signs of instability on touching down on the ground. The wide track of the two rear wheels on the tricycle chassis keeps the aircraft steady even in a cross-wind take off on a windy day.

As far as flying qualities are concerned, therefore, it is obvious that the "Owlet" has much to recommend it. In addition, it can be easily manufactured in large numbers, and is admirably suited to the training purposes of the immediate future.

Readers will realize that since many American aircraft ordered for delivery here are equipped with tricycle undercarriages, pilots will need a conversion course to get them accustomed to the extra wheel. New pilots intended for the "Airacobra," Lockheed "P 38," and Douglas "Boston," will also need to know the differences of the two-wheel and the "trike."

Performance as such, as far as trainers are concerned, is of no real importance. It is interesting to note, however, that the "Owlet," equipped with a 130-h.p. Cirrus "Major" engine, can attain a maximum speed of 125 m.p.h. and has a cruising speed of 110 m.p.h. The service ceiling is 13,000 feet, and the rate of climb 770 feet per minute.

Take off run is 210 yards, and to clear the 50-feet mark the "Owlet" needs 475 yards. Landing with the advantage of wheel brakes, which can be used to the full without fear of the aircraft turning up on its nose, is 150 yards. These figures are facilitated by the use of flaps, which incidentally give the plane a stalling speed of 53 m.p.h. The landing speed can be between 60 and 80 m.p.h. which is about the same as that of the "Hurricane."

The plane is equipped for night flying, the front of the two cockpits being that designed for the pupil, the instructor sitting in the rear with duplicate instruments, and overruling controls to cover any emergency. All night flying equipment is available, and a hood for daytime blind flying is being designed.

It would seem that the R.A.F. has now available the machine which will solve many of the problems of the present-day system of training.

WITH THE B.E.F. ON THE WESTERN FRONT

A PICTORIAL impression of a forward defence system showing the disposition of trenches, traps, etc. This drawing does not pretend to show any given part of the front line, also the lay-out of communication trenches, etc., would vary enormously with local conditions. Behind these works would come the stronger fortified positions of concrete emplacements and heavily armed casemates which we hope to describe in a later issue.

No action is taking place as this, if shown, would complicate the details and in its present form the position looks neat and tidy, but it would present a different picture after an artillery bombardment which, however, it is designed to resist. The positions are backed up by our own artillery in the rear. The concrete works shown are of medium protection and not considered strong points.

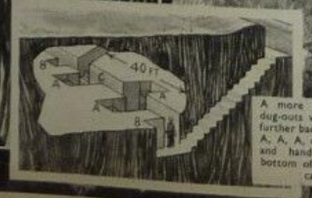
It will be noticed that an advancing enemy would be in for a very hot time and the traps, mines, etc., would be much greater in number. One section such as this would accommodate about one hundred men and three officers, but this again would vary with the local conditions.

The British troops at present in the front line are mainly well-known regiments, and before they took over went through three months of strenuous training in France under actual fighting conditions.

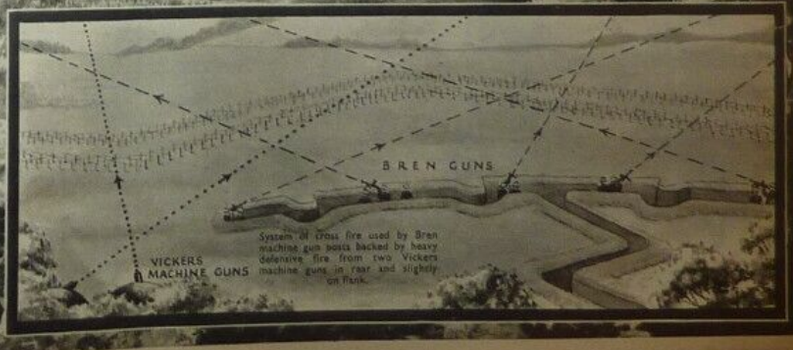
Section of typical fire trench showing parts.
1, Traverse protection against shell bursts; 2, parados; 3, drain; 4, duck board; 5, fire step or banquette; 6, brushwood revetment; 7, revetment anchorage; 8, ammunition recess; 9, sandbag elbow rest; 10, parapet 4 ft. 6 in. above fire step which is 18 in. from floor of trench.

TENTACLES
MINES
MINES
TRIP WIRES, FLARES, ETC.
ALARM GUNS
BARBED WIRE ENTANGLEMENTS
INFANTRY TRAPS
FORWARD OBSERVATION POST
BREN GUN
BREN GUN
ANTI-TANK MINES
TELEPHONE (BURIED)
OFFICER'S FIRE CONTROL POST
STONES
INFANTRY TRAP OR FOUGASSE
MINE
BREN GUN
FIRE TRENCHES
LATRINE
STEPS
TELEPHONE (BURIED)
COMMANDING OFFICER'S POST
MACHINE GUN EMPLACEMENT
DUG-OUT
C.O.'S DUG-OUT
STEPS
OFFICERS FIRE CONTROL POST
MOBILE ANTI-TANK UNITS
BREN GUN
COMMUNICATION TRENCHES
OFFICER'S LATRINE
DUG-OUT
SHELTER
STEPS
STEPS
DRESSING STATION
DUG-OUT
MACHINE GUN EMPLACEMENT
FIELD KITCHEN
MEDICAL OFFICER
WATER TANK
CONCRETE
STEPS

Details of a dug-out for five men in the forward sector of a trench system. Accommodation is made for three men resting while two are on duty. The entrance faces the rear of our lines to obviate the entrance of enemy shell fire.



A more elaborate system of dug-outs which would be used further back from the front line. A, A, A, dug-outs; B, B, bomb and hand grenade traps at bottom of steps; C, communicating passage.



System of cross fire used by Bren machine gun posts backed by heavy defensive fire from two Vickers machine guns in rear and slightly on flank.

ASHWELL WOOD

NORTH SEA BATTLE ZONE

By BERNARD HOGBEN

SCENE of many activities that have changed the history of the world, the North Sea is once again proving a battleground upon which many engagements of this war are being fought. When the Vikings made their marauding attacks on the coast of Britain no broadcast commentary heralded their approach, but in the thousand years that have passed the waters that surround our eastern shores have carried many would-be invaders.

From the Great War came the British naval victory at Dogger Bank in 1915, the Battle of Jutland that confined the German Fleet to over two years' enforced idleness, and the final scuttling of their naval vessels as revenge for defeat, in Scapa Flow.

History has once again repeated itself and the North Sea has again become the scene of some of the most exciting events that have happened in the past seven months. As a stretch of water to float the fighting ships of the opposing countries, the North Sea during recent months has lost a little of its former importance. Flying high over its angry waves, the warbirds of Germany and Britain have been spanning the distance between the two countries in an endeavour to obtain decisive tactical advantages.

Since the middle of October, when German warplanes first attacked this country, some seventy-five bombing and reconnoitring raids have been made. Starting with the unsuccessful raids on the Firth of Forth, German planes have systematically crossed the North Sea in attempts to disorganize our shipping. Lightships, which have always been considered outside the possibility of attack from any civilized nation, have been bombed and their crews machine-gunned. Fishing boats and even escaping lifeboats from sinking vessels, have become the prey of the Nazi airmen, but little success has been achieved from the air against warships or even boats carrying any form of anti-aircraft guns.

Most of the innumerable flights made by the R.A.F. over Germany have been started from bases on the North Sea. At least seven bombing raids have been made against the German Fleet lying at anchor at Heligoland, whilst others were directed at the fortified bases of Sylt and Borkum. Since Hitler produced the first of his not-so-secret weapons, the magnetic mine, we have maintained regular warplane patrols over the seaplane minelayer bases, with consequent loss of German enthusiasm for the use of their new destructive toy.

The sea has witnessed daring and tragic deeds performed. A U-boat slipped through the defences of Scapa Flow, and H.M.S. *Royal Oak*, an old battleship, was torpedoed and sunk whilst at anchor. A veteran of the last war found her grave with the ships she beat twenty years ago. But submarine successes have not been confined to the U-boats. The British submarine *Salmon*, after sighting the *Bremen* and allowing her to pass so as to avoid breaking international law, sailed into Heligoland and sunk an enemy cruiser and a U-boat.

The *Deutschland*, Nazi pocket battleship and sister to the ill-fated *Graf Spee*, escaped into northern waters to harass shipping. Capturing the American *City of Flint*, she put a prize crew aboard who sailed the ship to Murmansk. Diplomatic intervention resulted in the Russians handing over the ship to her American crew, and the next time the pride of the German Navy was heard of was when she sunk the gallant Merchant Auxiliary *Rawalpindi*. Totally outmatched in armament and gun range, the British naval merchantmen put up a fight which has added another laurel to the reputation our seamen hold in world naval history.

Down the coastline of Norway German ships have stealthily crept homeward or attempted to make the open sea. Once too often this was tried and the prison ship *Altmark*, one-time supply ship of the *Graf Spee*, found herself challenged by British destroyers. Into a Norwegian fjord she slunk, under cover of two gun boats. But the destroyer *Cossack* was determined to rescue the British merchant seamen languishing in a floating hell, and a tiny but very determined landing party boarded the German ship, shouting through the battened-down hatches: "The navy is here"—a phrase that is likely to go down in history to rank with Nelson's message on the eve of Trafalgar.

Around the coasts of Britain and Germany are minefields that protect the shores of the belligerent powers against any sudden sea attack. The mines laid by Germany in breach of international agreements keep our minesweepers constantly at work, but despite the Nazi claim that they are masters of the sea, the illustration on the left shows how British mines keep the German Navy within their fortified harbours.

The first seven months of this war have shown that an important way of beating the enemy is through economic warfare. To prevent goods from being imported into Germany, contraband control stations have been set up at various points. At these stations the ships of all nations are examined and the cargo searched for any unauthorized goods that may have as their eventual destination enemy importers.

R.A.F. leaflet raiders who have flown so deeply over German territory usually cross the North Sea on their thousand-or-more-mile trips, and the Air Security Patrol keeps up its daily vigil on enemy seaplane bases. Neutral vessels are constantly being attacked and sunk as a result of Nazi air and mine-warfare, but gradually the British Navy is getting a vice-like grip on all that happens in the North Sea.

U-boats are not to be found in nearly such great numbers as at the commencement of the war, and those that still prowl the sea have a very healthy respect for the aim of our bombing planes, and the high explosives we put into depth charges.

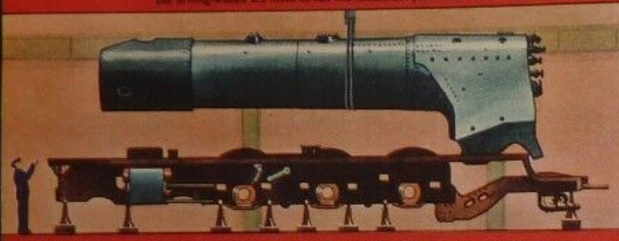
Should the German Fleet dare to put its nose outside the comparatively safe haven they have remained in since hostilities opened, the North Sea may become the scene of another naval battle that will bring further lasting glory to the sea "dogs" of Britain.

The BIRTH of the "CORONATION SCOT"

TO watch the building up, stage by stage, of the streamlined locomotives of the *Coronation* class built by the L.M.S.R., and to see the various parts assembled in their respective places is both fascinating and instructive. Below we endeavour to show in pictorial form the various aspects of locomotive assembly. These drawings have been made through the courtesy and co-operation of the London, Midland and Scottish Railway Company whose works at Crewe were specially visited by our artist. Our friends in the U.S.A. will shortly be able to see the newly-completed *Coronation Scot* train which is to make an exhibition tour of their country. The train will travel under its own power on a 3,121 miles tour, starting out from Baltimore on March 21, after which it will be on show at the World's Fair, New York, until October. Other locomotives of the same class now built are the Queen *Elizabeth*, Queen *Mary*, *Princess Alice* and *Princess Alexandra*. These new locomotives cost about £10,000 each and there are no fewer than 3,330 different parts. In the wonderful stores at Crewe any one of these parts can be found-out immediately on quoting its serial number. The drawings will help you to follow the sequence of operations.

Many score thousands of detailed drawings are prepared in the drawing office, and each part has its particular number in the specification.

STAGE 1: The two main frames are received from the machine-shop and placed on low jacks—squared up and straightened cross stays are fitted and markings made for cylinders, etc. Horn chasks for carrying the axle boxes of the driving-wheels are fitted to half one-thousandth part of an inch.



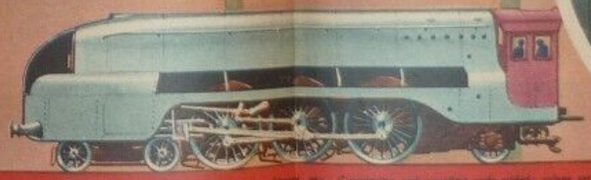
STAGE 2: Smoke-box and boiler lowered on to frames. Fixed at smoke-box end—expansion joints at firebox end. Axle boxes fitted to horns. Piston valves and oiling gear added.

STAGE 3: Bogie and frames fitted for wheeling: 6 ft. 9 in. coupled wheels run under, also leading bogie. Wheels lowered and wheels fitted into axle boxes. Leading bogie pin fitted.

STAGE 7: Paint shop. "Priming" coat applied and worked with stopping. Coat of lead-colour all over and finished with coats of blue and lined out.

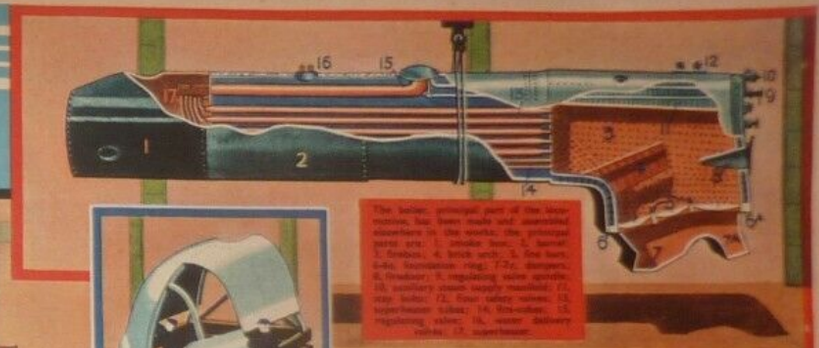
STAGE 3: Inside cylinders and motion plates are fitted and trued up with leading horn cheeks. Saddle casting for smoke-box placed in position. Outside cylinders also fitted and trued up with middle horn cheeks. Inside sight brackets and covering gear assembled.

STAGE 4: Boiler covered with non-heat-conducting material and the whole leather and firebox covered with cleading plates. Cab plate fitted and cab built up.



STAGE 6: Streamlined casing fitted, also buffers, chimney, etc. Connecting and coupling rods added, valves set; trailing bogie run in. Steam brake and train lines fitted. Springs and sanding gear assembled.

STAGE 8: Final stage. Placed over vacuum pit and tested for steam pipe leaks, if any. Loads on wheels tested for equal distribution. Now ready for the road. Handed over for trial run and adjustments made. Finally passed out for express duties.

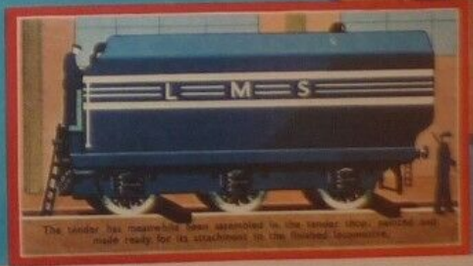


The boiler, principal part of the locomotive, has been made and assembled elsewhere in the works; the principal parts are: 1, smoke-box; 2, barrel; 3, firebox; 4, brick arch; 5, fire-hole; 6-to, foundation ring; 7-to, dampers; 8, firebox; 9, regulating valve spindle; 10, auxiliary steam supply manifold; 11, top boiler; 12, four safety valves; 13, superheater valves; 14, fire-valves; 15, regulating valve; 16, water delivery valves; 17, superheater.

The bulbous front streamline casing is first built up on wooden jigs to ensure accurate fitting on the engine.

Diagram of Walschaerts valve gear as used on the Coronation: 1, steam pipe; 2, piston valve; 3, piston; 4, piston rod; 5, crosshead; 6, guiding link; 7, combining lever; 8, radius rod; 9, link controlling valve motion; 10, reversing rod from cab; 11, eccentric rod; 12, eccentric; 13, crank arm; 14, connecting rod; 15, coupling rod.

View inside cab: 1, driver's seat; 1a, fireman's seat; 2, reversing lever; 3, steam sanding control; 4, brake valve; 5, large ejector steam control for brakes; 6, brake vacuum gauge; 7, Log book; 8, auxiliary steam manifold; 9, water gauges; 10, live steam injector control; 11, exhaust steam injector control; 12, regulating handle; 13, firebox steam jet control; 14, sand gun; 15, carriage warming reducing valve; 16, boiler steam pressure gauge; 17, carriage steam heating gauge; 18, fire door; 19, gangway folding doors.



The tender has meanwhile been assembled in the tender shop, painted and made ready for its attachment to the finished locomotive.

CAN INSECTS THINK?

M. ADDISON BRIGHT, F.R.G.S., discusses an interesting problem

NO one will deny that elephants, in common with horses and dogs, possess brains, but few will agree that reasoning power is an attribute of insects. This is possibly because the average person knows little or nothing about that vast order classified under the heading of "Insecta."

The dividing line between reasoning power or thought and instinct is such a slender one that it is on occasion exceedingly difficult to decide to which category certain actions should be relegated.

The diminutive caterpillar that devours its egg at once on hatching, and there are many such species, is generally considered to do so in order that birds, spiders and other natural enemies will be less likely to succeed in tracing it.

There is another theory, held by the world-famous French scientific observer, J. H. Fabre. He puts forward the novel idea that those newly-hatched larvæ, whose foodstuff consists of extra slippery or steeply-shutting leaves, need to manufacture silk thread as quickly as possible that they may lay a life-line wherever they walk on the slippery surface of the leaf. Otherwise a slip at that tender age would prove fatal, for they would never recover their food-plant.

He considers that the horny membraneous wrapper of its egg is transformed far quicker into the necessary silken mooring rope needed by the caterpillar than if it were to start feeding right away on a vegetable diet of green leaf.

Whichever of these versions is the correct one, and it may well be that the great Fabre's is, since many species do not devour the egg which housed them, therefore the fear of spiders and birds would hardly seem the right reason, but whichever it is it can scarcely be said to show the use of reasoning power on the part of the larvæ. It is merely an act of instinct.

Let us now turn to bees and ants, and examine cases of intelligence (?) in them.

Once in Florida some years ago a large species of ants forced their way through sheer weight of numbers into a beehive. As each ant entered it was seized upon by a "worker" bee and carried off on the wing. After a certain distance had been covered the ant was dropped and the bee returned. So, unfortunately, did the ant a little later.

On realizing this the bees must have weighed matters up, for it was observed that they now started flying much further afield and dropping the ants at such a long distance from the hive that they could no more find their way back. Thus, eventually, the bees were left victors of the field, but only because of their artful piece of strategem.

Another instance of thinking things out for themselves is the not altogether infrequent case of a mouse, or even frog, gaining entry to a beehive and later being stung to death while still engaged in "visiting." Normally bees will avoid dying in the hive if possible. But sometimes when the object is too large to be moved, as in the case of a frog or a mouse, the bees completely embalm the immovable fixture in a covering of propolis, a sticky, dark substance obtained from certain trees. This prevents putrefaction setting in, and the freshness and healthiness of the hive is, therefore, in no way interfered with.

Now for some examples of reasoning power among ants. The first two cases were observed and related to me by my friend, Miss L. E. Cheesman, a former lady curator of insects at the London Zoo.

A "nest" of ants was housed in one of the numerous "bays" in the Insect House. To confine them within limits a small galvanised iron trough filled with water surrounded the earthed-up "nest." The curator placed a dead mouse on top of the parapet that surmounted the steep bank down to the water. In half an hour's time she returned to find that the ants had endeavoured to dig the mouse out on the outside of the wall. The inevitable result was that it had rolled down into the water and two ants had been drowned.

The curator re-made the bank and replaced the mouse in the original position. Half an hour was again allowed to elapse on the expiry of which it was found that the ants this time had excavated the soil on the inside, thus allowing the mouse to roll down into the centre of the "nest."

On another occasion the larva of a certain beetle was introduced. This grub lives by constructing a conical-shaped hole in the earth and burying itself at the bottom, leaving only its hard, horny jaws showing above ground.

Ants and other insects come unsuspectingly upon the hole, fall in and are seized by those relentless jaws awaiting them at the bottom. Ant after ant perished in this manner. In vain did they marshal their forces and attack the enemy in mass formation. But all their tugging was fruitless; they could not dislodge the intruder.

They retired to think and soon hit upon a brilliant piece of strategem. They now proceeded to tunnel underground until they reached the grub's fat, white, fleshy body. This they now nipped with their sharp jaws, with the immediate result that the larva hastily wriggled out of its hitherto secure retreat and was thereupon triumphantly borne off by the ants to their "nest."

Yet another example. Some years ago two ants' "nests" were placed under careful observation, one consisting of black ants, the other of red ants.

One day it was noticed that great activity was being evinced by the red ants; they were busily engaged in throwing up protective surrounding earthworks. A few days later the black ants sallied forth to do battle with the reds.

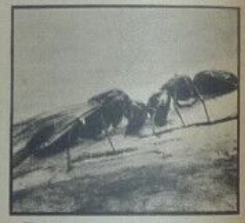
There were many casualties on both sides. From time to time the reds would send out their "stretcher-bearer corps" to bring in their slain and wounded. Occasionally an enemy ant would be carried in. No sooner would the mistake be discovered than the black ant would be hastily ejected.

A "working party" of these same black ants was observed one day to be presided over by a much larger black ant. Every now and then this "overseer" would single out some apparent laggard and administer a nip, a gentle reminder, presumably, that "go canny" principles are not tolerated in ant life.

Sympathizing with the working-class cause and in the interests of scientific observation, the observer ground the supervisor into the earth. At once the ants took counsel among themselves, and within a few minutes a new "foreman of works" had been installed.

While it is difficult to decide where instinct ends and reasoning begins, the instances quoted tend to show that, while in the case of the caterpillars there is every evidence of a complete lack of reasoning power, in the case of ants and bees there is every reason to reverse this decision, and that so far as hymenoptera are concerned the members of this order can definitely be upheld as possessors of reasoning power.

(Condensed from the "Outspan," S. Africa)



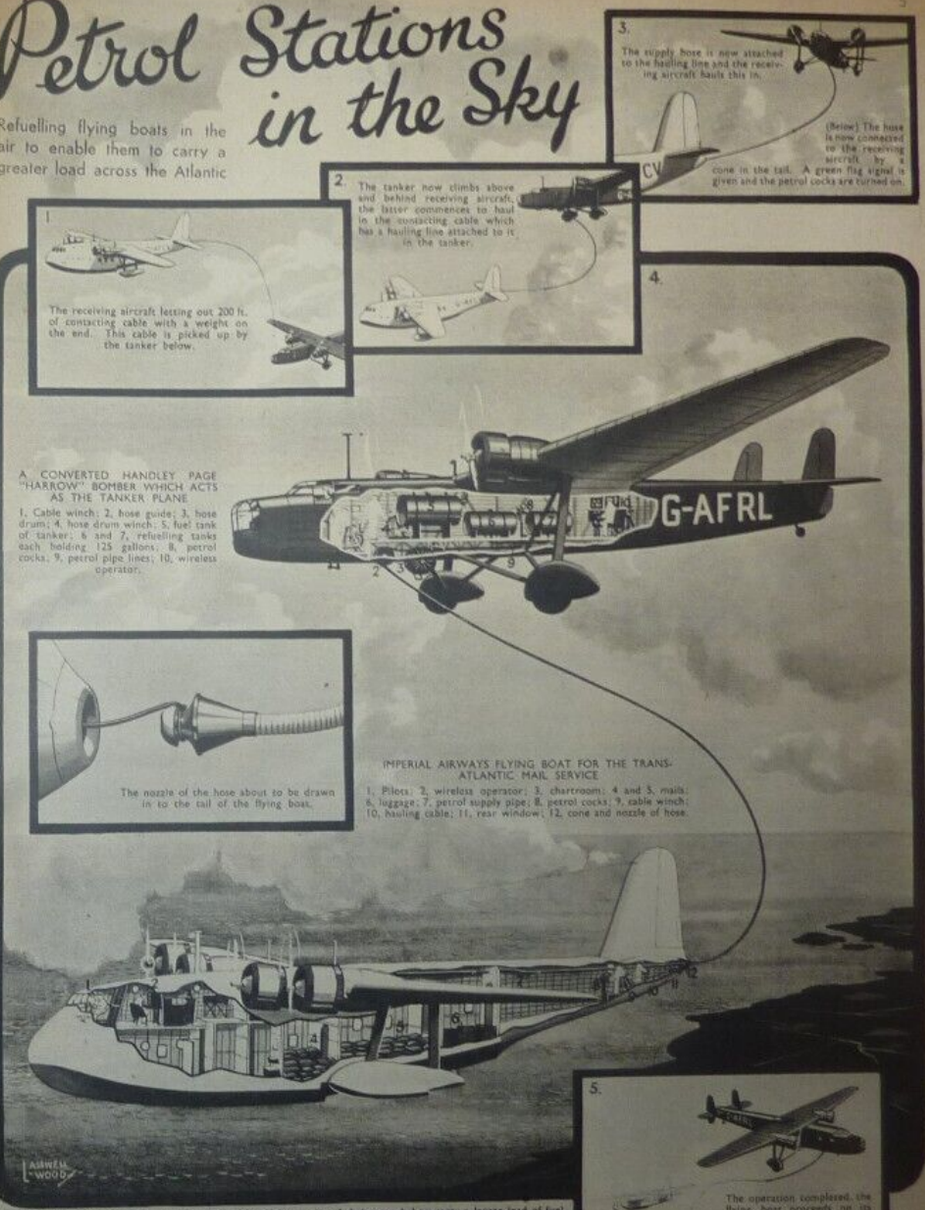
The queen ant and worker ant communicate by rubbing their sensitive antennæ together.

(Above) **Wood ants in mortal conflict.** *(Below)* **An ant giving some of its surplus food to another.**

A feast for the rest of the colony! This ant is tugging home a large fly.

Petrol Stations in the Sky

Refuelling flying boats in the air to enable them to carry a greater load across the Atlantic



A CONVERTED HANDLEY PAGE "HARROW" BOMBER WHICH ACTS AS THE TANKER PLANE

1, Cable winch; 2, hose guide; 3, hose drum; 4, hose drum winch; 5, fuel tank of tanker; 6 and 7, refuelling tanks each holding 125 gallons; 8, petrol cocks; 9, petrol pipe lines; 10, wireless operator.

The nozzle of the hose about to be drawn in to the tail of the flying boat.

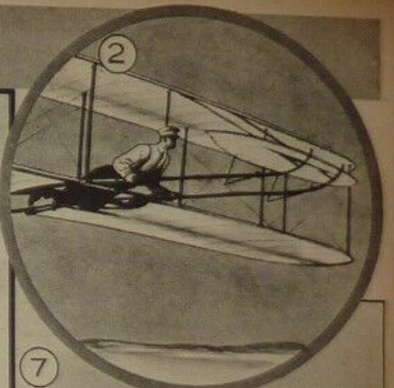
IMPERIAL AIRWAYS FLYING BOAT FOR THE TRANS-ATLANTIC MAIL SERVICE

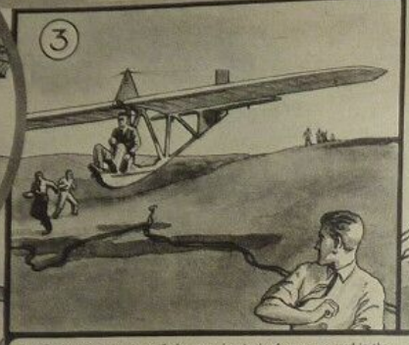
1, Pilots; 2, wireless operator; 3, chartroom; 4 and 5, mails; 6, luggage; 7, petrol supply pipe; 8, petrol cocks; 9, cable winch; 10, hauling cable; 11, rear window; 12, cone and nozzle of hose.

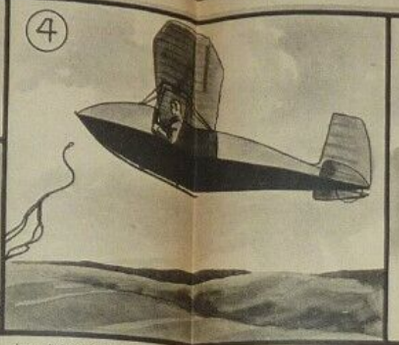
ASHWELL WOOD

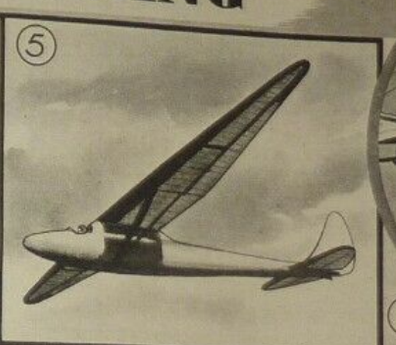
THE necessity for refuelling in the air is occasioned by an aircraft being needed to carry a larger load of fuel than it is able to take off with. In other words, an aircraft may need two thousand gallons of fuel to carry it on a single hop of a journey, but its take-off power may only enable it to lift one thousand gallons; the remainder therefore is taken on after the aircraft has taken the air. Imperial Airways are using a refuelling system on their transatlantic air route. Their specially designed "C" class flying boats have been prepared to receive one thousand gallons of fuel from a tanker aircraft by the process illustrated on this page.

GLIDING and SAILPLANING





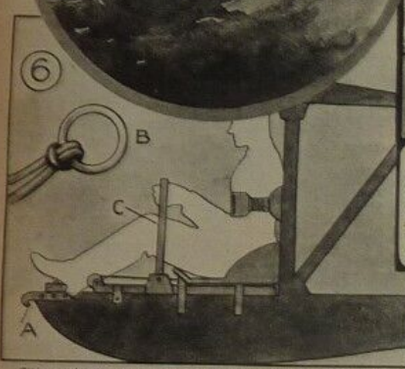




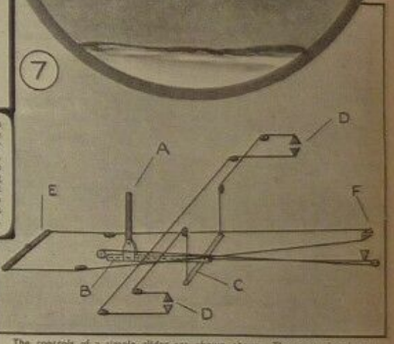
MEN have been hoping to fly for many hundreds of years; we read in the *Arabian Nights* of flying horses and magic carpets, and the folk-lore of every land has legends as fanciful. Some of these may have a foundation of fact, one in particular of an English monk, who is believed to have flown (or rather glided) for a hundred feet before he fell to his death. Since these very early days history records many experiments, some of which had a measure of success, but the first really scientific experimenter to take to the air on wings was Otto Lilienthal, one of whose early gliders is shown in Fig. 1. This fearless man with the help of his brother built many machines, and actually had made for him an artificial hill, fifty feet in height. In his day a light powerful motor was not available, but he had more than a thousand successful gliding flights before he was killed in 1896.

There is no space here to mention all the more or less successful experimenters from Lilienthal onwards, but two Americans, the Wright Brothers must not be omitted. One of their machines is shown in Fig. 2, a biplane in which the pilot lies at full length on the lower wing. In a similar glider, Orville Wright in 1911 succeeded in remaining in the air for nearly ten minutes, a record (for motorless flight) that was to stand for nearly ten years.

Illustrations 3, 4 and 5 above show three types of gliders that are in use today, and illustrate the advance made in motorless flight since 1911. The simple machine in Fig. 3 is known as a primary glider. This is used for training purposes only and is of simple construction, if breakages occur, repair is comparatively easy. An intermediate sailplane—Fig. 4—is a machine on which advanced pupils can learn to soar. (The difference between soaring and gliding is simply that in soaring one can not only hover in the wind but can make headway against it and climb.) A typical example of a modern sailplane is given in Fig. 5. In machines of this type flights of many miles are possible, and a skilful pilot can achieve a height of thousands of feet.

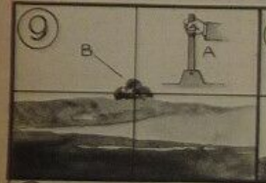


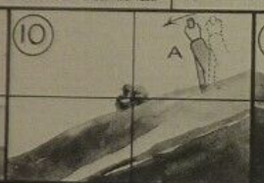
Gliders and sailplanes are generally launched by towing, the nose of the machine being fitted with a hook (A, Fig. 6), a double elastic rope with a ring B is fitted over this hook, and the ends of the rope are grasped by the launching crew (Fig. 8). In a primary glider, as shown above (Fig. 6), the pilot sits in an open seat against a padded backrest, and is secured to this by a wide and comfortable strap. To assist movement the control column or joystick C is between his knees and the rudder bar under his feet.

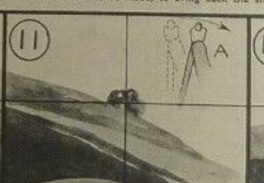


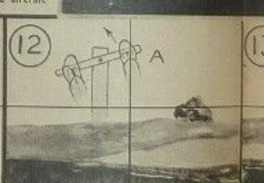
The controls of a simple glider are shown above. The control column support or stirrup A, is attached to a tube B, fixed to the fuselage but free to rotate. Fixed to the rear end of this tube is a "rocking-shaft" C, the ends of which are moved up or down by a sideways movement of the control column. Cables from the ends of this shaft are secured to the sectors D. There is one more control which is actuated by the pivoted bar E: this is the rudder F for which the pilot uses his feet, and which moves the rudder.

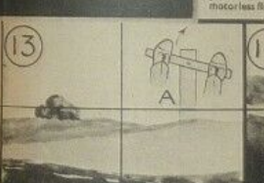
The pictures below from Fig. 9 to 16 show a very simple course in glider piloting. Strapped in his seat the pupil puts his feet on the rudder bar and takes the control column in his right hand. A mark on the horizon is memorized (such as B, Fig. 9) and this part of the horizon should be seen during the whole of the flight. The normal position of the joystick is shown at A in the same illustration, and while the horizon mark is as shown, the joystick is kept in this position. Fig. 10 shows the horizon tilting to the left, this is because the glider is tipped over to the right. To correct this the joystick is moved to the left as shown at A. It must be remembered that a gentle grip and gentle movements are used invariably with the joystick, there must be no suspicion of rough handling. In Fig. 11 the machine tips to the left, the horizon appearing to slope to the right. To regain the correct flying position a gentle rightwards control movement is made. When the horizon mark slides away to the right as in Fig. 12, a rudder movement must be made, to bring back the aircraft from the left turn to the desired straight flight. The right foot is pushed forward quite gently and when the nose of the plane points correctly the rudder bar is cencralized. If the horizon mark veers to the left as in Fig. 13 a contrary rudder movement is made. When the field vision appears as in Fig. 14 the machine is diving and flight is much too fast. This is corrected by pulling the control column back, as shown at A. A forward movement is made when the machine appears to be climbing. This is ascertained when the horizon declines below eye level as in Fig. 15. Illustration No. 16 is interesting at this point in showing the difference in climbing in a motorless soaring plane and a powered aircraft. Whereas the primary glider cannot climb for any period without stalling (falling backwards upon its tail); the sailplane by using rising air currents can climb with the control column centralized. The pilot of a motor plane pulls back the joystick to climb, and the relative positions of powered and motorless flight in climbing are shown: A, the sailplane and B the aeroplane.

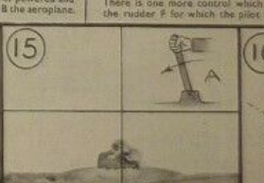


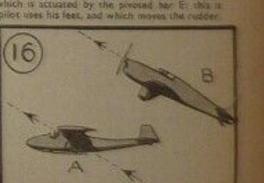




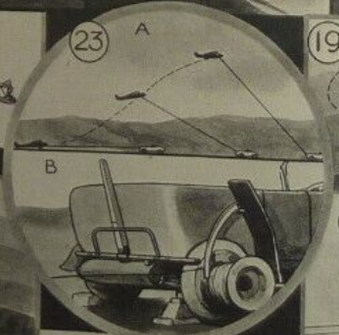




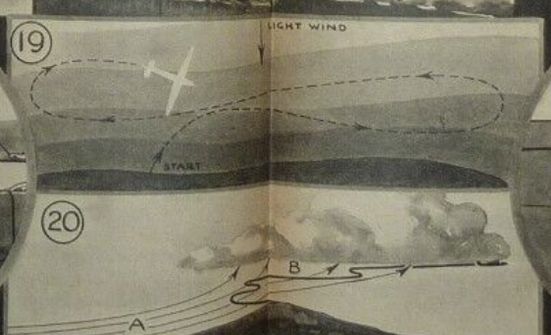




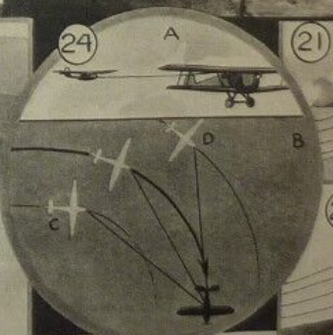
It is possible even in a primary glider to avoid obstacles such as trees, etc., as shown in Fig. 17, but there is a definite technique in doing this successfully. If normal flight continued would mean hitting the upper branches of a tree a backwards movement of the control column must be made to clear the obstacle. This will result in a crash if done too soon as at A, for the aircraft would probably sag down upon the obstacle. Correct procedure is given at B. When sufficiently advanced the glider pupil must learn something more of soaring. First lessons are given over a slope. Fig. 18 shows normal direction when flying along slope, notice how nose does not point in direction of travel.



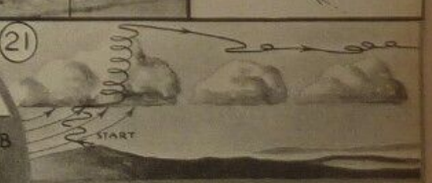
Here we give two methods of auto-towing. This is used to get sailplanes into the air and give them more height than in the usual "pulled" starts, and the illustration A shows the plane in relation to the car at three different stages. The cable is cast off when sufficient height has been reached. In this method the car is moving, but in illustration B it is used as a stationary windlass.



The method of flying mentioned in Fig. 18, is known as contour soaring and a further illustration of this principle is given above to show the method of making turns. The course followed in a light wind is shown, and takes the form of an elongated figure 8. On turning into wind, height is gained and a turn is made to follow the slope. Reaching the end of the soaring area, a turn is made into wind and away from the slope. When the other extreme is reached a similar turn is made (into wind and away from the slope). Cloud soaring is the most advanced type of sailplaning, and the means by which a skilful pilot can make long cross-country flights. Fig. 20 shows how the pilot is launched into a region of steady upward air currents A, from a hill and climbs into a region of wandering upward currents B, just below the clouds.



Aeroplane towing is only practicable for strongly built sailplanes, as great strains are thrown upon them. "A" shows towing positions of aeroplane and sailplane, which are about level. On a turn however, height can be regulated (as shown at B) for if the sailplane turns inside the line of the aeroplane's flight as shown at C, height is lost, while height can be increased by making an outside turn, as illustrated at D.



illustrated above are two further methods of cloud soaring. The first shows a distance flight above the clouds, and how the pilot takes advantage of each cloud. Rising into the upward currents under the first, he enters the base of the cloud and is flying "blind". This needs great experience, for his horizon is lost and he must rely on instruments (these are similar, though less in number to a normal aeroplane). Fig. 22 illustrates the use of up-currents on a thunderstorm front. The cold air is advancing uphill and beyond is and the cloud, warm air is forced up as shown. A competent pilot travels along the storm front gaining height all the while as shown.

Continuing

PRISONERS OF THE GESTAPO

"Good old chaw," he murmured. "It is wonderful the number of uses to which a really first-class artificial hand can be put."

Straightening out the fingers which had served so well as a grappling iron, he turned up his right coat sleeve and relaxed his hand before getting busy. Fastening an end of the rope to one leg of the desk, he lowered the other end out of the window and called to Wassermann to make it into a slip-knot and secure it under his armpits. When a faint call from the pathway told him that the old artist had obeyed his instructions, he started to pull him slowly up to the window.

His human burden was scarcely halfway up when, from the direction of the house, came a resulting crash as the Gestapo men succeeded in breaking down the door of their prison. The next moment, there was a wild scramble in the garden and a bullet smashed viciously against the brickwork of the building a hair's-breadth away from the swaying figure of the old artist.

Hearing desperately on the rope, Colin succeeded in hauling Wassermann to the edge of the window sill. Then, with a prodigious heave, he dragged him inside just as another bullet ricocheted off the brickwork above his head. Gasping and groaning, the old man fell on the floor, but this was no time to delay.

Relentlessly, Colin dragged him to his feet and then, supporting him with one arm, they crossed to the door of the office. All was dark on the building outside, but by the aid of his lamp, the Englishman discovered the staircase that led down to the music storerooms. The sounds from the garden had now ceased, and it was obvious that the Gestapo men were on their way to attempt to intercept the fugitives before they could get clear of the building.

However, owing to the length of the street in which stood the artist's house, it would take the pursuers quite ten minutes to reach the quay-side, and by that time Colin and his companion would, if luck was with them, be safely away.

Down the stairs they hurried, their feet resounding in the echoing stillness of the old building, and Colin, who had brought a tight watchman on the premises who would attempt to stop their flight, Colin handed over his torch to Wassermann to carry and himself produced his automatic. But no challenge greeted them as they reached the ground floor, and in a matter of seconds they were stumbling at the massive main doors of the warehouse.

A hasty examination sufficed to show that they were locked from the outside, but close by was a narrow door that was apparently used by people in entering and leaving and which saved the necessity of opening the main doors. This, too, was secured, but without a moment's hesitation Colin smashed the lock with a well-directed shot from his automatic.

Peering cautiously round the gaping door, Colin took stock of the surroundings. A crescent moon cast a faint light on the cobbles of the deserted street and touched the surface of the river with smudges of silver, but the night was too dark to enable one to see more than a few yards ahead. Slipping back into the young Englishman, reflected, it would be possible to reach the quayside without being seen by any prowling officials who might be lurking were distance away in the shadows.

Not daring to run the risk of leaving his car unguarded, Colin decided to scorch for a suitable craft. Colin took Wassermann by the arm, and together the two men hurried across the cobbles in the direction of the river. Moored to the quay were several boats including one to which had been fitted an entirely new type of engine pattern, and it was into this craft that Colin assisted his friend.

A hasty examination satisfied him that the engine was in reasonably good order and the tank more than half filled. From the markings on the little boat, it appeared that she was used by the local river police, which accounted for the outboard motor, for no ordinary civilian could have hoped to obtain a supply of petrol.

After a couple of fruitless efforts, Colin managed to start up the engine, and then calling to Wassermann, who was sitting huddled in the bows, to cast off, he took his place at the helm. The next moment the motor boat was chugging slowly away from the quay—and not a moment too soon. For as they glided past the stone wall, the sound of a car travelling at great speed reached them, and round the far end of the quay appeared the Gestapo staff car.

Two of its occupants, clinging precariously on the running board, sighted the escaping craft and promptly opened fire with their automatics. But the darkness of the night, added to the pace at which their car was travelling, impeded their aim, and the bullets sang harmlessly overhead.

"We've beaten them, my young friend," exclaimed Wassermann, gleefully. "Now we need worry no more."

Colin grunted noncommittally. He had no wish to damp the optimism of the old man, but he realized all too well that they were by no means out of danger. It was not likely that the Gestapo would be content to sit by and allow so valuable a prize to be snatched from their grasp without making strenuous efforts to recapture it.

And, as the sinuous knew, several miles of Channel waters rives would have to be traversed before they could make a safe landing and from there head for the secret aerodrome where the *Silver Phantom* was waiting to carry them to England and safety.

As though in answer to his thought, the drone of a high-powered motor suddenly reached him and a powerful searchlight cut through the blackness like a sword of fire. Up the river raced a powerful speed boat, the water spuming white round her sharp prow as she slashed her way through the dark wavelets. From side to side swept her searchlight, thrusting searching fingers into the darkness that was no longer a shield to the two men in their little boat.

Suddenly the beam was focused fully on the craft and the next moment a shot from a light gun mounted in the bows boomed across the water. A pillar of spray spumed from the river some yards ahead of their track, drenching them. Obviously, it would be suicide to try to hold out against an opponent so infinitely faster and better armed and Colin, obeying the warning shot, ruefully switched off the engine, allowing the little boat to lose way.

Sweeping down on them like some vengeful bird of prey, the powerful launch drew alongside, and scarcely had she touched than two men, armed with rifles, leaped on board. There was nothing for it but to obey their orders, and their captives clambered over the side and on to the deck of the motor cruiser, covered by the Gestapo men.

The official in command barked a sharp order and the boat gathered way as she swung round in a broad arc and headed down river. Not until she was well set on her course did the leader of the Gestapo turn to his prisoners, and there was a menacing gleam in his eye as he spoke.

"A very clever attempt, my dear Herr Wassermann," he growled. "But one that you and your companion will live to regret. The Gestapo knows just how to deal with fools who defy its authority!"

Turning on his heel, he strode into the little cabin, leaving Colin and Wassermann to stand shivering with cold on the most exposed part of the deck, under the menacing guard of the armed men. It was a position in which only the most desperate measures could possibly save the prisoners, and Colin's brain was busy examining every loophole for escape as the craft drove its way through the inky waters, her powerful engines pounding and throbbing as they worked at full pressure.

Keenly the Englishman took stock of his surroundings. Dark though it was, he was able to identify the blurred landmarks sufficiently to identify the route they were taking. And it was with a sinking heart that he realized they must be heading for the private landing stage that led to the district headquarters of the Gestapo, some four miles downstream from the city.

Once there, no power on earth could save them from the tortures that awaited them in that grim, five-storied building with its shuttered windows and soundproof cellars where so many ghastly crimes were perpetrated on the unhappy victims of the secret police.

The Gestapo men had searched them for arms and had taken Colin's automatic, so any hope of launching a surprise attack on his captors was now gone. It certainly seemed as though the days of the Winged Avenger were numbered, but it was not of himself but of his companion that Colin thought as he stared downstream. If only he could save him, he would die happy.

Suddenly he started involuntarily and strained his tired eyes towards the jetty for which they were heading, now only some quarter of a mile distant. From low down, close to the water's surface a light winked thrice and vanished, and with a quickening of his heart he recognized it as the calling-up signal he and his cousin, Mostyn, used.

Again that pin point of light flashed its signal. A pause. Then, like some strange firefly the light flickered a brief message in the code employed by the two Englishmen.

"Prepare to jump when near pier. Trust me," flickered the light. Brief though it was, the message sent hope surging through the Englishman's heart. Mostyn was aware of their plight and, his cool, calculating brain had devised a plan for their rescue.

Without turning his head, Colin spoke softly out of the corner of his mouth. "Work your way slowly to the starboard rail," he breathed. "And be ready to jump when I give the word. Understand?"

An almost imperceptible inclination of the head told him that the artist was ready to follow his orders. Then, inch by inch the two prisoners edged towards the rail until they were but two paces from it. The outline of the wooden jetty was becoming clearer every moment and Colin braced himself for the desperate venture that would mean freedom—or death.

"Get ready to jump," he breathed. Then, as his companion tensed himself in readiness, Colin suddenly yelled at the top of his voice: "Look out. We are being rammed on the port side."

So urgent was his cry that the attention of every Nazi on board was focused on the danger that appeared to be threatening their craft. And in that second of time, the two captors acted. Seizing the old artist round the waist, Colin lifted him lightly in his arms and with a mighty heave flung him clear over the rail into the river. Then, as the guards turned at a shout of warning, he sprang lightly on to the rail.

As he poised there, a bullet tore through the sleeve of his coat but the uncertain movement of the boat which the helmsman had instinctively swung off her course at the warning Colin had yelled, made accurate aim a difficult matter. Just as another shot cracked from the rifle of a second guard, the airman flashed downwards to cleave the water in a perfect dive.

With powerful strokes, he struck out, swimming under water away from the direction the Gestapo motor cruiser was taking. Not until his breath was almost giving out did he come to the surface and dashing the water from his eyes, peer round him. Some thirty yards away, an indistinct shape loomed out of the darkness and a few seconds later his supporting arm was round Herr Wassermann.

Meanwhile, the launch had reached the shelter of the jetty, men in her stern firing in the direction they imagined their prisoners had taken. Treading water, Colin saw the launch draw alongside the steps and then the powerful beam of her search-light flashed on. It was obvious that the Gestapo men would use it to pick out their victims who could then be either shot or pursued.

But before the light was able to be swung round towards the middle of the stream, a roar that seemed to tear the very heavens with its fury came from the jetty as great tongues of lurid flame shot high into the night sky. And mingled with the thunder of the explosion came the sound of splintering woodwork and the screams of men caught in that ghastly holocaust.

Silhouetted against the red inferno, the motor cruiser, now nothing but a twisted mass of metal, rose high in the air as though flung by some giant hand.

Then silence settled once more on the river.

A few moments later, the thud-thud of a motor reached Colin and, regardless of danger, he raised his voice in a loud hail. A low, black motor launch drew near and with a sigh of relief Colin recognized the form of Mostyn at the wheel. It was the work of but a few seconds to help Wassermann on board and to follow him. Then, hugging the shadows of the farther shore, the boat sped rapidly up stream to the landing stage where Mostyn's car waited to take them to the secret aerodrome.

"When I get your signal from the house," Colin's cousin explained, "I kept an eye on things and when I realized that you had tried to escape by river and had been nabbed, I took this boat along to the Gestapo jetty where I planted a nice little surprise in the form of a time bomb that I had left in my secret hide-out for just such an emergency."

"It was ticklish work, but the darkness helped me, and you know the rest."

Colin grinned appreciatively. "You always were a master of understatement," he retorted. "But I wish I could have left my trade mark for the Gestapo."

"I saw to that, too," Mostyn chuckled. "On my way to the quay, I posted an envelope to the head of the Gestapo. And in it I put a single sheet of paper with a drawing of an aeroplane just as you draw, plus the words 'Lowest quotations for new jetties supplied.'"

He paused for a moment, then added with a grin: "But the best of it was that I didn't stamp the letter. Fancy having to pay to receive a note like that."

Getting enemy secrets . . . with a camera

Pursuers, planes soar into the air. Over the enemy's zone they make daring dives, taking shots after shots. Members of No. photographic reconnaissance planes, shooting in flights which may last for hours.

Wassmuss " Armchair Science " on sale this thrilling 100-page issue containing many fascinating articles, and features as well as showings of the world's best "Armchair Cameras."

Does this issue contain the secret of success? Does it tell you how to develop your personality? Does it explain the principles of salesmanship? Does it tell you how to speak in public? Does it tell you how to write a good letter? Does it tell you how to train your memory? Does it tell you how to develop concentration? Does it tell you how to develop will-power? Does it tell you how to develop self-confidence? Does it tell you how to develop initiative? Does it tell you how to develop personality? Does it tell you how to develop salesmanship? Does it tell you how to develop speaking? Does it tell you how to develop writing? Does it tell you how to develop

WEAPONS OF THE WILD

AND WHAT MAN HAS LEARNED FROM THEM

IN the animal kingdom survival goes to the fittest, and in the fight of birds, beasts and fish against their natural enemies most are equipped to provide the means for continued existence. Many species prey upon others for food, but Nature has given those that are preyed upon natural protective instincts to prevent extermination.

Through the ages science has learned many lessons from Nature. It has discovered that birds and beasts have been created in different forms so that they can continue to live and increase, and play their parts in the natural scheme of things. Many of the lessons have been applied to everyday life of the human race, but in the development of man's weapons against his fellows it is very easy to trace the natural instincts that have been applied.

In the early days of mankind men travelled on foot, but as the centuries passed they looked up into the heavens and saw the ease with which the birds soared through the skies. Man thought that he could fly too, and although Nature had not endowed him with wings he started to experiment until he learnt to make a ship that would carry him through the air.

Just as the hawk swoops upon its prey from the wind wafted sky, so man learnt to build fortresses of the sky; bombing aeroplanes that can rain death upon his enemies. But just as Nature provides its antidote to the ravages of the attacking beasts of the jungle, so man has learned to take a tip from his natural surroundings and provide a defence against his preying brother.

On these pages are shewn a number of the weapons and defences of mankind, and their similarity to the provisions of Nature can be readily seen.

When man first watched the graceful birds flying leisurely through the sky above him he decided that he must discover the means of flight.

The tactics of the hawk as it swoops down upon its prey are very similar to those of the bombers which cast their shadows over the cities of the world.

The rhinoceros with its scaly hide charging through the jungle has taught man that offence in the form of a tank, is the best method of defence.

As the antelope charges its foe with lowered head and antlers at the ready, he reminds us of the soldier of today with bayonet at the ready.

If sharks can catch their prey by a sudden attack from under the sea why couldn't man make a ship that would come up and destroy the enemy?

The dangerous snout of the swordfish as he makes an attack on his foe has taught man to make torpedoes to destroy surface craft.

Crocodiles push their heads above the water and climb the banks of the river to obtain their food. Man has learned how to make tanks that can travel on land or water.

The smoke curled round the branch of the tree is indistinguishable from the foliage, and man has developed camouflage to disguise him from his enemies.

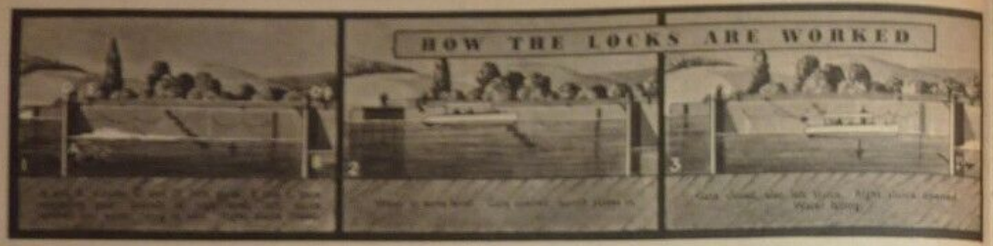
The evil smelling odour which the skunk radiates has its counterpars in the poison gas that men use against each other in the world today.

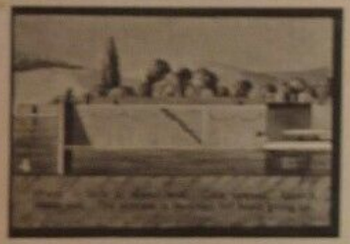
The porcupine's prickles and the barbed wire entanglements of the modern army both serve as a defence against foes.

Balloons that are protecting our big cities from air attack are designed to produce similar results to an aeroplane as the web which the spider weaves for the fly.

In the cuttlefish excreting its black inky cloud to hide its manoeuvres from its prey we find a similarity to the smoke screen put out by man's fighting ships to enable them to move unseen.

Marching battalions of ants as they cover the ground in perfect formation, have taught soldiers how to advance to battle.





CONTROLLING *Father Thames*

ENGINEERING SKILL HAS PROVIDED ENGLAND'S FIRST RIVER WITH LOCKS AND WEIRS SO THAT NAVIGATION AND WATER CONTROL ARE POSSIBLE

"Old Father Thames keeps rolling along
Down to the mighty sea."

SUBJECT for song and poem, England's chief river starts its mighty course down to the sea as a number of small streams in the Cotswold Hills. Over two hundred miles of this great inland waterway stretch from Thames Head, the reputed source, to the estuary on the Essex and Kent coasts.

Through rural scenery of a broad valley the upper reaches of the river pursue a winding course. Other streams add their water to it in its early, lazy passage to the sea, and its main channel sends off many narrow branches. As it flows through a gap between the Chilterns and the downs of Berkshire it ceases to flow over the clay soil of Oxfordshire, and passes through beautiful wood country over chalky soil.

River widening. London's great river sweeps on through the city, taking in the waters of such rivers as the Brent, Wandle and Lea.

From the estuary to Teddington the river is controlled by the Thames Conservancy who are responsible for the water level and navigation. Maintenance of locks, weirs and other works come under their care and it is safe to say that very few rivers have had more engineering control exercised over them than the Thames.

Below Teddington to the sea the Port of London Authority exercise their jurisdiction.

Now there would be only a small flow of water in the Thames if it were not for the elaborate system of weirs, which, in fact, form the river into a series of reservoirs so that water can be held back, and its flow regulated by sluice gates.

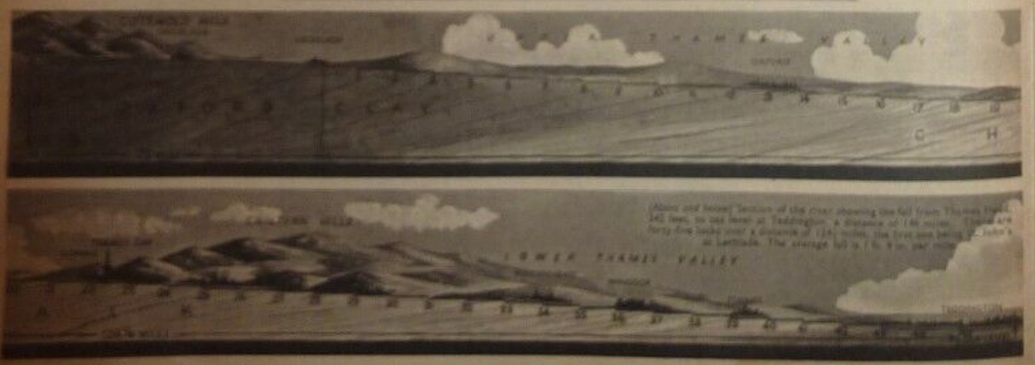
The Conservators of the Thames have a large number of weirs and subsidiary weirs under their control, also the locks which make the river navigable. It was in 1771 that an act of Parliament authorized the construction of the first lock at Mortlake. From that time a number were built at various points above the town. About 1812 the Corporation of London started similar constructional work as far down the river as Teddington.

As elaborate canal system provides water communication between the river and various parts of the country. Thus London can send its transport over the winding waterways which lead to the industrial centres of England.

Above the city of London the river provides a source of exercise and amusement. Motor boats, sailing boats and rowing boats can be hired by those who desire this form of recreation, and with a fixed tariff for passing through the locks, many people enjoy sailing the upper reaches. Upon its waters famous regattas take place, perhaps the most notable of which is that held at Henley, although the most interest is displayed in the Oxford and Cambridge boat race rowed between Putney and Mortlake.

Below the locks the river becomes tidal, so that the tide from the sea rises and falls below the lock gates.

The Thames flows quite normally in summer at about one-eighth knot, but the flood stream flows at five to six knots



Sitting at the keyboard and instrument panel the operator can produce words and sentences. Buzzes and hisses are mixed in the throat of the Voder and moulded into vowels and consonants.

BY DUPLICATING THE HUMAN THROAT THIS MACHINE TALKS LIKE MAN

The TALKING MACHINE

AN electrical device which, under control of an operator at a keyboard, actually talks, was demonstrated recently at the Franklin Institute, Philadelphia.

Known as the Voder, it is a development of Bell Telephone Laboratories as a scientific novelty to make an interesting educational exhibit for the Bell System's displays at the San Francisco Exposition and at the World's Fair in New York. It is built, except for its keys, entirely of apparatus used in everyday telephone service.

The Voder creates speech. It is the first machine in the world to do that. Individual vowels and consonants have been made by a variety of instruments, but they have never been linked into connected speech.

Seated at a keyboard, something like that of the old-fashioned parlour organ, an operator can carry on a conversation simply by pressing keys, singly or in combination. It takes a good deal of practice and some time to learn—not as much time as it takes the human to learn the mechanism he is born with, but still quite a while. And it talks with what might be called a slight electrical accent. Nevertheless a skilled operator can make it say what she wants.

Designers of the Voder provided it with electrical equipment corresponding to the two kinds of speech sounds. One kind of sound is made by forcing the breath through the mouth, past the tongue, teeth and lips.

Turbulence in the air-stream sets up a hissing sound which contains a great many vibration frequencies. Some of these are reinforced by resonances in the mouth cavity; that is the way in which are made all the sounds of speech when one whispers, and such sounds as s, th and f.

In the Voder there is an electrical hiss, and with some of the keys the operator can control its quality so as to make those sounds. Other keys make the "step consonants" like t, k, and p.

Other kinds of sound enter into human speech, most importantly in the vowels, like a, e and o. It comes from the vocal chords, and is very complex and somewhat musical. In the Voder, therefore, there is an electrical source of sound corresponding to the vocal cords; and there is a pedal for changing its pitch and for giving to speech a rising or falling inflection as desired.

When the operator wants the sounds made by the vocal chords, instead of whispered sounds or consonants, an arm rest switch is depressed. Then the particular parts of this vocalized sound which are wanted are selected by playing the proper keys.

The source for this sound is the so-called "relaxation oscillator" which gives a sawtoothed wave in contrast to the smoothly rounded wave of a pure musical note. This saw-toothed wave has a fundamental note which gives the whole sound a definite pitch.

Broad changes in this pitch mark the difference between male and female voices; gliding change of pitch over a smaller range constitutes inflection. The Voder may be posed as a man or a woman by turning a knob; it may state a fact, ask a question or soliloquize a word according to the motion of its pedal.

When one talks one shapes the mouth cavity so that some particular parts of the complex sound come through clearly while other parts are suppressed and unheard. This makes the difference between the vowel sounds.

For the same purpose the Voder is provided with ten keys. Each of these operates a variable attenuator to control the current in a definite frequency range. Source of current for each attenuator is an electrical filter which picks from the saw-tooth wave one group of its overtones.

Normally each attenuator is on open-circuit, so that no sound comes through. The vowel-sounds require the selection of only one, two, three or four ranges of overtones; the other ranges contribute nothing to the sound.

In human speech, some sound is found in every range, but the Voder seems to speak most understandably when the unimportant overtones are suppressed.

Considering all the keys, there are twenty-three different sounds available to the Voder operator. By combination of keys she can mix these sounds and by the fingering she can control the shading.

All speech sounds can be produced, but the number any operator can make use of depends on her finger dexterity; even granted the ability, only long practice will bring skill. The young ladies who operate the Voder at San Francisco and New York were selected from more than three hundred telephone operators; and through long practice they have acquired a sufficient vocabulary to converse on ordinary subjects.

Sounds in the Voder's repertoire are not confined to those of the human voice. Bleating of sheep, lowing of cattle, grunting of pigs, and even the tat-a-tat of the woodpecker can be produced with perfect realism.

The Voder is an outgrowth of fundamental researches in telephony carried on in Bell Telephone Laboratories. Homer W. Dudley in the course of one of these researches developed a speech synthesizer which could be controlled electrically by a speech analyzer.

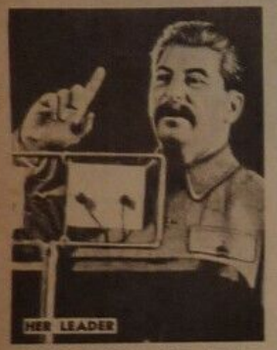
These pictures show the keyboard from which a skilled operator is able to produce the sounds of the human voice.

Successful outcome of his work was demonstrated in September, 1936, at the Harvard Tercentenary in Cambridge. When the Bell System exhibits were projected for the exhibition at San Francisco and New York, the southern part of the apparatus seemed to offer possibilities for development into novel demonstration which would have educational value even though its use the imitation of speech sounds could be shown.

Mr. Dudley and H. S. Knowles thereupon constructed a model which has been put into form for exhibition by W. A. MacNair of the Laboratories' technical staff. Difficult tasks of working out its linguistic possibilities and a technique for its operation were undertaken by S. S. Watkins, who developed a course of training and instructed a corps of operators.

To the onlookers, the Voder is known as "Pedro" as a reminder of an interesting bit of history. In 1850 the telephone itself had just been invented, and it was on display by Philadelphia's "Centennial Exposition. Dom Pedro, Emperor of Brazil, was asked to listen while someone talked from a telephone set in another room. Suddenly the voice of Pedro's host, Alexander Graham Bell, was heard. "My God! It talks," he exclaimed. Ever since Dom Pedro alive in Philadelphia makes his words not instead of hearing voices by wire and radio from his capital, but is he heard words that had never come from a human voice, his exclamation of 1876 might well be repeated.

What is Happening in RUSSIA



JOSEPH STALIN Born in the Tiflis Province in 1879, of peasant stock. Headed a group of revolutionary leaders who came into power in 1925. Although holding no official post is the real ruler of Russia's millions. Under his leadership the people have a strict dictatorship government, and very little initiative is left to the individual.

RUSSIA the mysterious: the enigma of Europe. What is going on behind the scenes in this country, which, whilst near us on the map, is still less known to most of us than remote tribes in the African jungle?

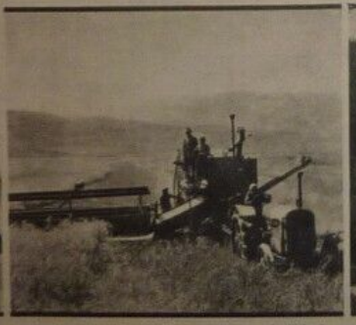
Her army and air force are reputed to be the largest in the world, yet of her strength or weakness very little authentic information is available. Have the vast plans made to build up industries and provide self-sufficiency for her 180 million people really succeeded? Is this vast country, three times the size of Australia, all that her friends make her out to be, or is most of her apparent advance in science and culture just window dressing as her enemies tell us?

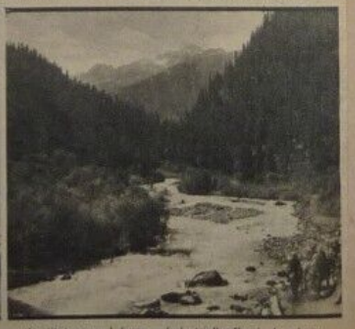
We do not know. After twenty-two years of the Soviet regime the outside world has little accurate information about the everyday lives of the ordinary people. Under the Tsars we know that the people were ignorant and superstitious. Claims are made that every one now has the opportunity to acquire learning. Certainly Russian films that have been seen in England show that this branch of art has unusual methods of expression.

But at this time, when Russian aggression has negatived all her peaceful protestations, it becomes doubly difficult to assess how far her advance along the road of progress has really taken her. Even her much vaunted military preparations seem to be of problematical efficiency.

VOROSHILOV Leader of the Red Army. Considered as probable successor to Stalin. His job is similar to that of our Minister of War, but owing to purges in the army over recent years it is claimed that he cannot command such experienced officers as are at the disposal of most other European war chiefs.

RED SQUARE Moscow centre of Russia's commercial and political life. In the famous Red Square where reviews are held and each May Day celebrates the 1917 revolution, no tramcars are allowed to spoil the beauty of the large open space. On one side rise the huge walls and towers of the Kremlin, residence of Russia's dictator, and there are a row of fir trees growing along the grey walls of Lenin's tomb. From the top of the Kremlin flutters a red flag which is floodlit at night. At the tomb of Lenin stands an armed guard, tribute to the man who built the new Russia. Moscow is typical of other Russian cities. Fine modern buildings contrast with ancient Oriental towers and churches. The above picture illustrates a typical Russian festival in which mechanized units of the army play an important part.

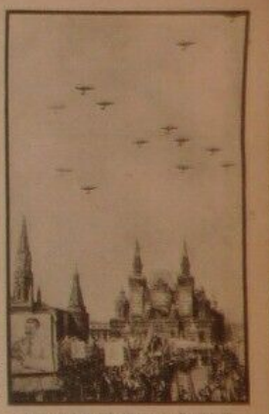




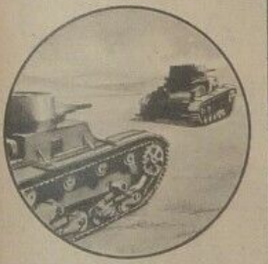
HER WEALTH Rolling plains and soil suitable for growing every type of cereal, vegetable and fruit makes the country a great agricultural one. Wheat, rice, sugar beet, cotton, tobacco, are just a few of the products of the land which communal farming runs. Parts of Russia are rich in coal, oil, lead, zinc, copper, gold, silver, radium, etc., and the mining of these valuable metals helps the country to a measure of self-sufficiency. Great herds of cattle are rapidly being established and livestock rearing is being developed on the State owned farms. Industrially Russia has been producing a great deal of the manufactured products that her people need, and the various plans that have been put into operation are all aimed at making the country independent of imports whilst maintaining export trade.

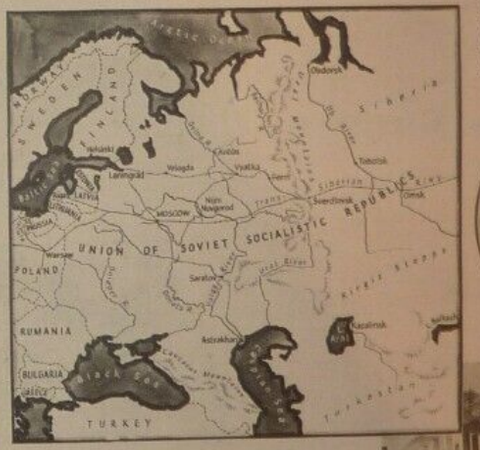
HER ARMY Reports say it consists of 1,800,000 officers and men, with probably another 18,000,000 trained reserves. Much faith is pinned on tanks and mechanical transport, which according to latest reports is reliable. Mechanized war material is said to average the amazing figure of thirteen horse power for every man among Russia's fighting millions.

NAVY As a modern fighting unit is only two years old, previously being only a coastal defence force. A shadow navy is rapidly being built up. A large number of submarines are known to have been built under the new programme, but the number and types of surface craft built in recent times are a mystery. Battleships and cruisers built pre-war were reconditioned between 1929-35, and a number of these are known to have been fitted with heavy modern armaments and anti-aircraft guns. Recent Russian naval recruiting figures indicate that a big early expansion is planned and from the few new craft that have been seen by people outside the country it would seem that their Navy will soon reach large proportions.

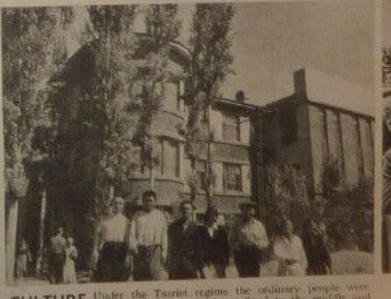


AIR FORCE Figures for Russia's air arm have been stated as around 10,000 planes of various kinds, but definite numbers are not known. Mass parachute jumping was a new aerial technique developed by the Russian airmen, which has since been adopted by a number of other countries. Machines are mostly copies of American, British and German designs. Four types of engine are most usually employed: Shinn, Gnome Rhone, Wright-Cyclone and the Soviet AM34.

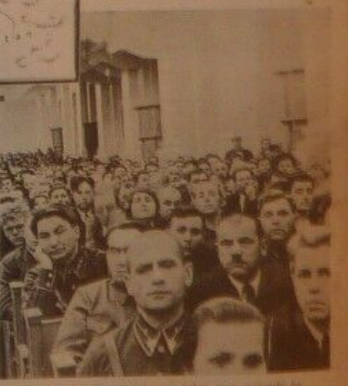




WOMEN WORKERS In farming districts the women work side by side with the men. They share the same jobs and are granted the same privileges as men. There are women soldiers and engine drivers and a girl is as likely to become a skilled mechanic as a local factory as her brother.



CULTURE Under the Tsarist regime the ordinary people were illiterate. Learning was confined to the middle and upper classes and few working men in rural districts could even write their names. In the past twenty years the numbers of poets, writers and artists have been steadily increasing. Improved educational facilities have allowed the workers to study either in their spare time or be released from ordinary employment if ability warranted additional training. The cost of education is borne as a charge by the State.



THE PARTY Politics are taken very seriously by every one in Russia. Men and women have equal rights in voting and the ballot is secret. Each town or community has its own "cell" or committee and conferences held periodically. Because of Russia's vast expanse there are a number of tiers representing these meetings, and a full attendance brings some 2,500 delegates.

SCIENTISTS AT WAR

The Ministry of Supply's experts in every branch of Applied Physics represents the greatest mobilization of scientific talent ever attempted. These experts keep up a continual research into problems affecting the supply of munitions and kindred items.

WE scan our newspapers eagerly for the latest communiqué from the Western Front. If it is trite in its brusqueness we turn to read what is happening on the Home Front. It's only on rare occasions, however, that we read anything about the scientific side of the "Supply Front."

In 1914 when we read of Munitions, we understood very little more than guns and shells needed by the soldier to carry on his job. In those days industry was not organized to play any part in the country's struggle against the enemy. Making shells was a matter of profit, like any other commercial undertaking.

But the experience of twenty-five years ago has taught England that a dogged fighting spirit in the hearts of its men isn't sufficient to win a modern war. All the developments of science, the technical research, and the inventive genius of the man-in-the-street must be mobilized, co-ordinated and exploited to provide the sinews of war.

And this is being done. At the commencement of this war experimental and research establishments under Government control had a large staff of personnel at their disposal, men experienced in the scientific needs of peace, and those trained at the Military College of Science. Five of these establishments have researchers engaged in work on such divergent subjects as explosives, ballistics, metallurgy, radiology, anti-gas, searchlights, radio communications, and mechanical and electrical apparatus.

With every passing year war becomes more scientific. Peace time discoveries are distorted until they become deadly weapons. Research and the application of the latest discoveries are needed to find devices to counteract new weapons.

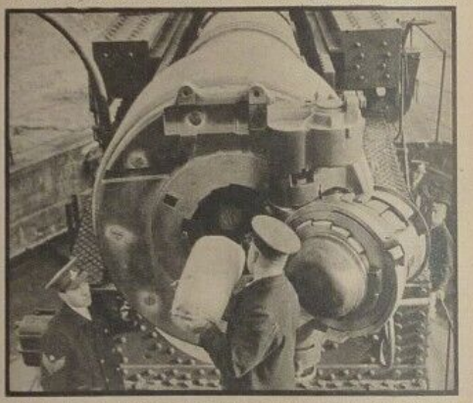
Under the official wing of the Ministry of Supply, all this wartime research is carried out, as just one branch of their work. Closely linked with such laboratories as the Department of Scientific and Industrial Research, the application and direction of knowledge to the solution of war problems is going on all the time. Knowledge has to be adapted; diverted to military needs.

A typical example of this is radio. Military wireless sets are needed in large quantities, and it would seem on the face of it that ordinary apparatus could easily be adapted. But service sets have to meet special requirements. They have to be portable, weather-proof, easily operated, and repaired, and are combined transmitters and receivers. Many problems arise in designing such apparatus, especially as they have to maintain two-way communication between trenches, with the minimum of aerial.

Think back on the inventions that sprang out of the last war. Quite a formidable list of things we now take for granted come to mind. The inventor who saw in the agricultural tractor the possibility of a mobile fortress and persuaded the Government of the time to build tanks, can never have visualized the seventy-ton monsters with which the French did such good work in the first days of the war.

Aeroplanes and radio were new inventions in 1914, but the need for their quick development for military purposes was realized and we all know the rapid strides made by them in the last quarter of a century.

The Great War taught the value of co-ordinated research. From that time dates the establishment of three major sections of Government scientific work. For all these years researchers have been engaged in solving the problems arising from agriculture and fisheries, medicine, and the needs of industry.



Testing the new giant 15 in. gun at the Ministry of Supply's experimental headquarters recently. This giant naval weapon is capable of piercing one foot thick armour and costs £1,000 every time it is fired. (*Above*) **Loading the gun with the 400 lb. charge of cordite that is needed to hurl the one ton weight shell through the air.** (*Left*) **Shells ranging in size from fifteen inches downwards all of which are tested at the Ministry of Supply's experimental establishment.** (*Below*) **You can't see it but there goes £1,000 in the form of a shell travelling through the air at 1,600 ft. per second.**

Secret weapons may be let loose with a fanfare of horrific propaganda, but it is reassuring to know that counter measures can always be developed when a host of skilled scientists are available to concentrate their brains on finding a solution.

Air peril has developed anti-aircraft guns, balloon barrage, sound locators and other defensive measures; the use of poison gas is combated with respirators; and tanks are unable to achieve the same quick results anticipated on their first use.

The ideas which first saw the light of day from 1914-1918 have been improved. Sound-ranging, for instance, is a product of the last war which has been developed beyond all recognition. To make the apparatus as perfect as it is today meant designing ultra-sensitive microphones. Photographic recording instruments of cinematographic type suitable for field use had to be made. Problems connected with correction allowance when sound is travelling "down wind" required solution.

Even before the war plans had to be made for countering any new weapons that might be sprung upon us. Scientists like the rest of humanity cannot be expected to read what is going on in the other fellow's mind. But specialized knowledge has made it possible for them to intelligently anticipate what he *might* be thinking about.

Reference is kept of all discoveries and inventions. Our Government may consider them too inhuman for use, even in war, but it means that if the enemy use them we have defence methods ready. With the mines came paravanes; with submarines, depth charges; the bomber is harassed by fighters.

Here is an example of anticipatory research work with which we are all familiar. As we carry round that little cardboard box we may heartily curse it, but behind the respirator it contains there is over twenty years of co-ordinated research between chemists and physiologists to give us an antidote against any known poison gas.

During all these years they have examined and classified hundreds of poisonous compounds, and then set about devising methods to destroy their death-dealing effects. They found that these so called gases could be divided into two classes—gases and smokes. An airtight mask was made with a canister containing absorbent material to trap smokes, and special charcoal to soak up gases—in much the same way as a sponge absorbs water. As long as the respirator fits tightly so that the only air breathed comes through these filters we can thank the experts for a perfect protection against war gases.

So in war, as in peace, the work of our scientists goes on. Now the search for knowledge is more grim; on its results so much depends. But in the organization of the Ministry of Supply, we have a band of men who will not let our enemies outstrip us in knowledge.

"AEROVISION"—WARTIME TELEVISION

It is well known that several governments are employing scientists to work out a system of television communication between the front line and the heavy guns and headquarters behind the lines. The details of the methods used are of course quite secret, but the sketches on this page are an artist's impression of one way in which television could be used.

At A we show a large bombing plane flying over a front-line sector which is being subjected to a heavy artillery bombardment. Normally observation of this attack would be limited to posts in the front line or fixed observation balloons connected by telephone to the gun positions in the rear. The plane, however, is fitted with a television camera and is able to view the course of the attack at any point and transmit simultaneously the picture of what it sees below.

Illustration B gives some idea of how the television section of the aircraft might be equipped.

Fig. C represents an army lorry fitted with a large screen television viewing receiver, and standing by it senior officers, who are able to see the effect of the attack at the exact moment it is being carried out. This position is in telephonic communication with the gun position shown at D., so that the aim can be corrected.

CONQUEST of the INVISIBLE

NEW MICROSCOPE HAS NO LENSES BUT REVEALS MINUTE ORGANISMS WITH AID OF ELECTRONS. MAY HELP SCIENCE TO FIGHT OBSCURE DISEASES

THE microscope has been pushed by fantastic ingenuity to its limit. Many things are too tiny to be seen with ordinary light. Now a super microscope has been invented which begins where the common instrument leaves off.

With its aid many mysteries long veiled in the safety of smallness—mysteries of disease, of human heredity, of the structure of flesh, stone and steel—may soon yield, before a new acuteness of vision.

Each improvement of the microscope has made man more conscious of his own huge complexity. Under the simple magnifying lens the lines that produce a fingerprint become deep depressions like the furrows of a contour-ploughed hillside. Under the compound microscope a drop of blood from that finger becomes a lake in which swim little pink globules—the red blood cells.

WONDER WORLD OF NATURE

Under the super microscope we may learn more about the molecules called haemoglobin which give the cells their colour and enable them to keep us alive.

There is endless wonder in peering down the drawn-out tube that leads to Lilliput. A man sits at a table with one eye open to the world of ordinary scale; his other eye plunges him into an amplified miniature world with its own weird assemblage of flora and fauna.

Queer creatures live out their lives within the compass of a water drop. Here is the domain of the amoeba, that jellylike prototype of life's emergence from primitive ooze; it consumes food by the simple process of flowing completely round it.

Here one finds that other rudimentary animalcule, the paramecium, its transparent, slipper-shaped body failing to conceal its several little round stomachs. Here are the microbes, those that produce disease and those we label "good," each dividing to produce two daughters. Here are yeast cells, budding off baby generations.

Under the enlarging eye a fine human hair becomes a hollow tube. Woven textiles reveal their warp and weft like basketwork. Paper degenerates into a jungle of fibres. Coloured pictures become a meaningless aggregate of black, blue, red and yellow dots. Polished metals show odd-shaped crystals in disorderly array, while carefully crystallised chemicals display the beauty of frost.

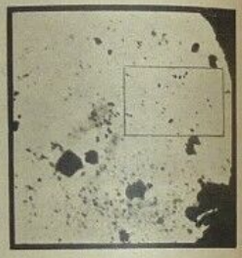
EXAMINING BACTERIA

It is just one hundred years since Schleiden and Schwann found that all living creatures, animal and plant, are aggregates of microscopic cells. Later in the nineteenth century came the fundamental discovery of modern medicine—that single-celled plants (bacteria) and single-celled animals (protozoa) cause many of our diseases.

Many infectious diseases were definitely pinned on microbes seen and photographed through the microscope. But for other diseases — measles, infantile paralysis, yellow fever — no guilty creature could be found. The invisible culprits were called viruses. To detect them a super microscope was wanted.

Among those who longed for sharper vision were biologists studying the body cell and the nucleus within it. In the nucleus the microscope showed them chromosomes, which they identified as the carriers of heredity. Within the chromosomes, biologists reasoned, there must be special units—genes they named them—each specifically determining some characteristic, such as red hair, green eyes or big ears.

(*Above*) The section shown in oblong enlarged 63,000 times.
(*Below*) Colloide silver magnified 16,500 times.



ELECTRONS INSTEAD OF LIGHT

But so small are the genes that, biologist H. J. Muller has estimated, all the genes needed to determine the heredity of the world's next generation of 2,000,000,000 persons would, if gathered from their scattering among the earth's future fathers and mothers, fill the space of a single aspirin tablet.

The chemist, too, longed for a keener artificial eye. He had drawn imaginary pictures of complex molecules—of rubber, proteins, insulin, hormones, vitamins. These pictures work—they help him to synthesize and analyse. But are they true? A super microscope might give the answers.

Why could not the microscope get down into this region? The fault lies not with the instrument. The fault lies in the medium; light is too coarse for these refined purposes.

A few years ago, microscopes were built which used ultra-violet radiation, the kind that causes sunburn; it is about half the wave length of visible light. With these more detailed pictures were obtained. The new super microscope uses electrons instead of light.

The electron itself, though the most abundant thing in the universe, is a discovery of modern science. It is the tiniest unit both of matter and electricity.

The super microscope, which makes use of beams of electrons, has appeared in several forms.

In all these instruments, electrons are emitted from filaments and accelerated to high speed by high-voltage electric fields. The beams are focused, and directed through the object to be viewed, by means of magnetism. A vacuum is maintained so that the speeding electrons will not suffer collisions with molecules of air.

Bacteria already have been photographed 20,000 times larger than life. And when the great technical difficulties that still beset this new art are conquered, its performance is expected to show phenomenal improvement.

Compared with its ultimate possibilities, the super microscope has not even reached the stage that was represented for the optical microscope by the crude lenses through which Antony van Leeuwenhoek, in 1674, first revealed the strange Lilliput of life within the compass of a water cup.

LENSES STILL USEFUL

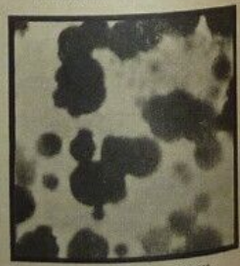
To be sure, the electron instrument has limitations that will always leave an honoured place for the glass-lensed microscope. Those living animalcules that Leeuwenhoek saw dancing around in water, and that thousands of observers after him have studied, may never be seen alive in the light of electrons.

The electron beam is a sort of death ray and, besides, the vacuum in which it operates is hardly the best medium to sustain life. But this may not be a serious handicap to the super microscope's career, for the tiny world it taps is largely of a scale at and below the transition stage between life and the inorganic.

(*Condensed from "N.Y. Times" Magazine*)

The electron microscope enlarges a single bacteria in this way.

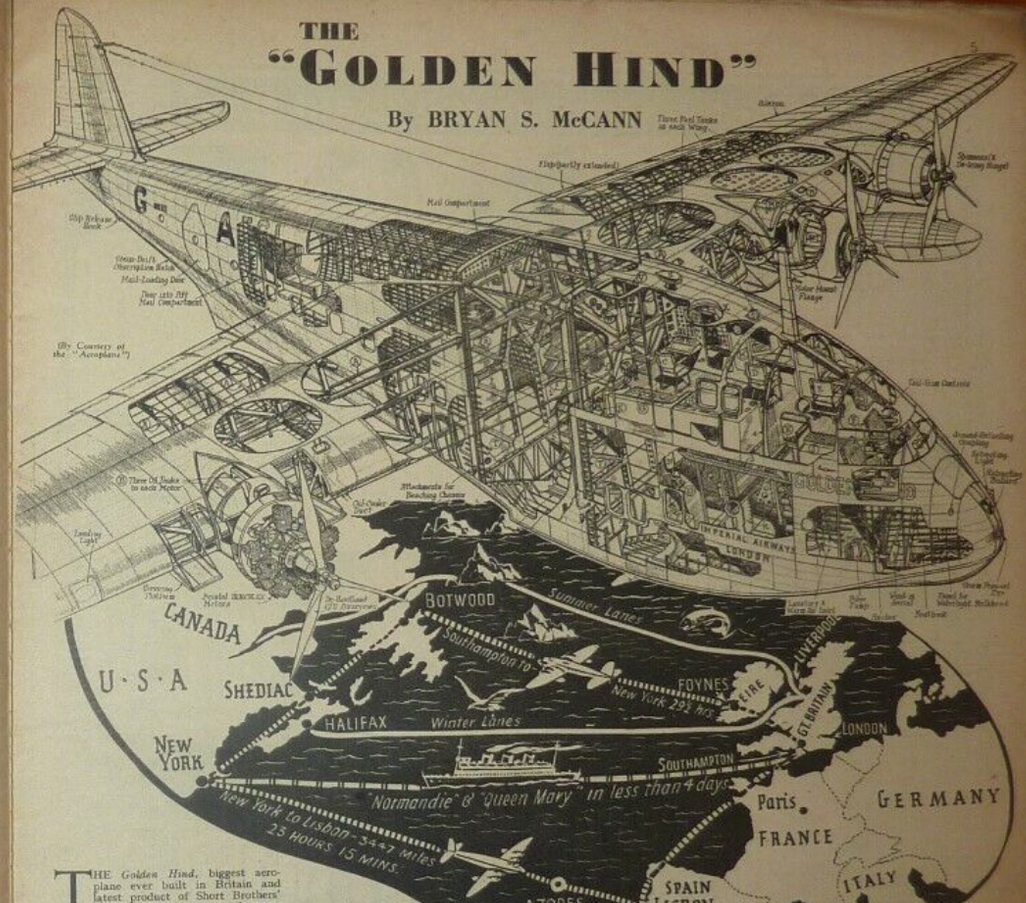
The greatest magnification obtainable with the ordinary microscope shows bacteria in chain formation.



Colour technique is helped with the new microscope. These two pictures show the difference between the appearance of particles under the light microscope (*right*) and the super microscope (*left*).

THE "GOLDEN HIND"

By BRYAN S. McCANN



THE *Golden Hind*, biggest aeroplane ever built in Britain and latest product of Short Brothers' factory at Rochester, made some of its trial flights recently.

This plane, specially constructed for Imperial Airways as a passenger and mail-carrying machine, is the first of a series of three flying boats; the remaining two, *Grenadier* and *Grenville*, will be ready shortly.

This type of plane ranks as fourth biggest machine in the world. The first, the German Dornier "Do.X," is now resting in a German museum, the outcome of a daring step taken ten years too soon.

The American *Yankee Clipper* and her three sister ships are now operating the transatlantic service for Pan American Airways. Others of these planes are to recommence the Pan American trans-pacific service which ceased with the sinking of the *Sawaan Clipper* last year.

The third machine, that is even bigger than the *Golden Hind*, is the French *Lieutenant Vaisseau de Paris*, which has had a very hectic career, including one period during which she sank at her moorings and had to be salvaged from the bottom of the harbour.

The *Golden Hind*, then, is next. How does she compare with these other boats? Will she uphold Britain's tradition as a fine aircraft-building nation?

There can be no doubt about this last point. One merely has to trace the steps that led to the construction of such a wonderful plane to realize that Short Brothers would not have constructed this plane unless they had been absolutely certain about what they were doing.

For years past it has been Britain's code in the air to put safety before speed, comfort before size, and, therefore, the *Golden Hind* is the first really big flying boat that has ever been built for Imperial Airways.

During these years, however, important steps, vital to the success of such an enterprise as this giant machine represents, have been taken.

The *Scion Senior*, a small landplane, was actually the first real herald of the *Golden Hind*. This plane was constructed in 1934. It was a half size model of the first "Empire" flying boat.

Two years later *Canopus* appeared. She was the first of the "Empire" flying boats of which there are now twenty-eight operating with Imperial Airways insignias on their bows.

The success of the "Empire" flying boat was immediate. It was thoroughly efficient and immediately successful. In fact, the machine proved so reliable that it was converted into the Short "Sunderland" to be used by the R.A.F. for military purposes.

Following the "Sunderland," Shorts started on four strengthened "Empire" flying boats, known as the "C" class, for Imperial Airways transatlantic service.

Since the "C" class, the first of which is just launched, the *Golden Hind* has been built, and the *Grenadier* and *Grenville* have rapidly progressed.

It is obvious, then, from this brief history of the craft's development, that the *Golden Hind* is the product, not as a spasmodic design straight from the drawing board, but rather years of practical experience in the building of this type of boat.

One important feature, however, that will possibly delay the launching of this machine is its size.

This is the first time that British authorities have been asked to give a certificate of airworthiness to a machine of such size, and naturally test flights will take some time. But in the end the *Golden Hind* and its sister ships will come through with flying colours and prove to the world that a flying boat can be constructed of simply enormous proportions as long as it is backed by practical experience in both construction and flying technique.

The span of this giant machine is 134 ft. 4 in. and the length 103 ft. 2 in. This makes it twenty feet more in the span and fifteen feet longer than the "C" class machines.

The top speed is twenty miles an hour faster than the *Yankee Clipper*, and the cruising speed is 155 m.p.h.

The four engines are Bristol "Hercules" air-cooled radial sleeve-valve motors with a maximum take-off power of 1,500 h.p. The four engines then give a total take-off power of 5,520 h.p. The power for level flight is 1,830 h.p.

The boat has been designed to have an all-up weight of 73,500 lb., or 32½ tons, which is 20,000 lb. heavier than the "C" class flying boats and 35,000 lb. heavier than the "Empire" boats.

The range in still air is to be 3,400 miles, but the boat has been designed to carry a certain weight, including a crew up to five, against a headwind of 40 m.p.h. for 2,500 miles. This will be quite sufficient to carry it across the Atlantic.

The plane is equipped with a transparent retractable navigating dome, let into the top of the fuselage just above the navigator's cabin.

One million rivets went into the construction of the hull, the outer covering of which is only one twenty-eighth of an inch thick.

The interior decorations has not been installed in the plane yet. This will not be done until she has passed through most of her flying trials. Imperial Airways on this point state that the interior will not be finally settled until it has been decided whether the machine will be used on long, medium or short range services. Such items play an important part in settling the interior of a plane.

It is known, however, that there will be two decks. The upper will be for accommodating the crew and have three large mail compartments. The lower deck, excepting for the forward and aft baggage storage compartments, will be entirely for the accommodation of passengers. Details other than this, however, are still unsettled.

The plane can carry 130,000 half-ounce letters, which will be surcharged at the rate of one shilling and threepence. The passenger fare will be somewhere around seventy-five pounds per person and, in addition, there will be room for 1,000 lb. of freight.

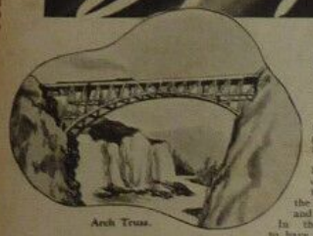
Being able to carry such loads as this over the Atlantic it will be surprising if Imperial Airways do not find the service a paying proposition.

Before any passengers are carried, however, the *Golden Hind* will probably make several transatlantic flights, carrying nothing but mail, continuing Imperial Airways safety first policy of letting pilots get used to both plane and route before taking passengers.

Britain's first really big flying boat has been completed. With it Britain will shine the world that big flying boats can be really successful if they are backed by a sound organisation and practical experience. Look back to the *Golden Hind* and her sister ships!

Symphony in Steel

By BERNARD HOGBEN



Arch Truss.

BRIDGES—THE STEPPING-STONES OF CIVILIZATION

ON holiday one year in the north of England, I arrived at the small village in which I was to stay, the morning after a great storm had flooded the lazy little river that separated the few homesteads from the nearby town. With the flood waters had gone the eighteenth-century bridge.

Instead of a short run of three or four miles along a well-kept road, we had to circle some forty miles over hill and dale, and negotiate lanes that may have been quite satisfactory for iron-clad cart wheels, but were certainly not suitable for the rubber tyres of a motor car.

Bridges are one of the things most of us take for granted. All our lives we have been accustomed to cross from one side of a river to the other, with very little more thought than we waste on the engineering skill that has gone to the making of the roads on which we walk. It is only on the very rare occasions when something happens to a bridge that we realise how essential it has become to our life.

In the days before bridge building made it possible for men to travel directly from one place to another, shallow parts of rivers were used as fords, or boats ferried the people across the water.

As civilization developed, the construction of bridges became more ambitious. Probably starting with a rough-hewn tree trunk across a narrow stream, the science of building bridges has expanded through the ages to a stage where engineers of the present day construct the giant girder and concrete spans we see in many parts of the world.

Experts tell us that the age of a bridge can be calculated from the diameter of the piers which support the span. Through the centuries the span of the arches has increased and the piers have become narrower. In the British Isles they appear to have started with an average span of twenty-five feet, and reached seventy-five feet in the eighteenth century.

Very different is the modern steel and concrete construction from the first London Bridge which spanned the Thames as its shops and houses stood towering above the water beneath. The upkeep of this bridge, which was a masterpiece of construction in its time, was obtained from the rents of these buildings built upon it, and tolls which were collected from all foot passengers who wanted to cross the river.

Before the eighteenth century, nearly all bridges had gateways. These served two purposes. In the event of war, the gates could be closed and the enemy held at bay. In peace time the tolls were collected at the gates, for in those days it cost money to walk across a bridge.

Bridge building necessitates a wide practical knowledge as well as scientific training which will enable a designer to know exactly what type of bridge and what materials should be used in a certain place. There are many types of bridges to choose from, and one of the first considerations will be whether it is to be of a fixed variety or whether it is to open.

In the two types of bridges there are five main classes, and a brief description of each will show the enormous work which is put into providing means of crossing from one bank of a river to another.

The first type of fixed bridge to be described is known as an "independent span." In this kind, each span rests on a pier, and does not exceed eight hundred feet in length. The side girders usually have some kind of webbed arrangement, and with this type stresses can be calculated very accurately. An example of this class is found in the Hawkesbury bridge in Australia, which has seven spans each of four hundred and sixteen feet.

"Continuous-span" bridges have the advantage of being lighter than the independent span type, but stresses are much more difficult to determine, and temperature expansions more difficult to allow for.

The most beautiful type of fixed bridge is the "arch" type. These can be built in a large variety of materials, and some constructed from masonry are still to be found, which date from the time when the Romans occupied Britain. Made of stone, these arch types have spans anything up to two hundred feet, and London Bridge, which is of this type, has spans of one hundred and fifty-two feet.

Modern bridge construction makes use of reinforced concrete and arch bridges corresponding to those made from brick and masonry can be built with this material. These may be built in either of two ways; on the spot, or by assembling pre-cast sections.

When very wide spans are necessary the "cantilever" type is often used. Spans may be as great as three thousand feet, and these are linked together with a suspended section. The principle upon which these main spans are suspended is an adaptation of balanced leverages. Each span is balanced on a central pier, and its shore end is anchored down.

A notable example of this type is the famous Forth Bridge. It consists of three huge double cantilevers which are joined by two short connecting sections. Spanning the Forth near Edinburgh, this great engineering feat, costing nearly two million pounds, stretches for one and a half miles.

For the largest spans of all, which, in theory anyhow, can be up to seven thousand feet, the "suspension" type of construction is used. This consists of a platform suspended from heavy wire cables or chains, which are passed over high towers near the shore, and anchored in the ground.

An example of this type is the recently opened Golden Gate Bridge, San Francisco. Claimed to have the longest span of any bridge in the world, four thousand two hundred feet from tower to tower, this latest addition to man's engineering prowess took four years to build at a cost of about seven million pounds.

Near each shore, seven-hundred-and-forty-six-foot towers were erected to carry the thirty-six-and-a-half-inch-thick cables upon which are suspended a six-lane roadway. These roads are two hundred and twenty feet above high-water level so that they allow the passage of great liners.

Bridges that open to allow shipping to pass are also constructed according to five different types. The most-often seen is the "swing span." This type is pivoted so that the bridge swings round and allows boats to pass on their way. In smaller bridges of this type motive power may be by hand, but the bigger kinds use hydraulic or electrical machinery.

Most of us know Tower Bridge, and have stood and watched it throw up its arms to allow some steamer from a far-away country to pass on its way. Built on a principle known as the "bascule," this bridge works on pivots and counter-weights. The two great leaves which rise to allow a ship to pass are each one hundred and sixty feet in length, and weigh, with their counterweights, one thousand two hundred tons each.

A steam engine working a force pump drives water, so that by just pulling a lever the cranks start moving and the heavy bascules are raised.

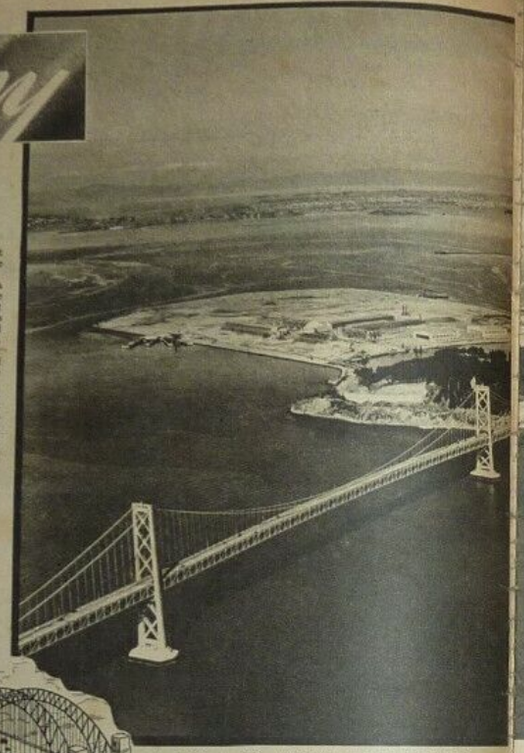
Another type of opening bridge sometimes found in docks is known as the "rolling" type. The moving span is mounted on wheels or rollers, and is rolled back on the approach. Very few of this type have been constructed as there are difficulties in arranging for the span to be moved bodily in this fashion.

The "vertical lift" type is quite popular and has many advantages. Wire ropes passing over pulleys mounted on high towers and weighted at one end take the weight of the bridge, which can easily be raised sufficiently to allow shipping to pass. Bridges of this type with a lifting span as great as three hundred feet have been built.

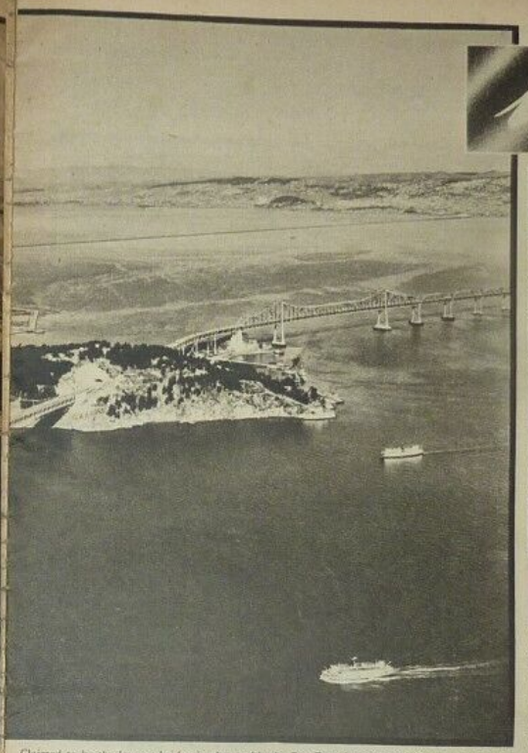
Last type of the opening bridges cannot really be described as opening, although it is usually put under that heading. It is called the "transporter" type, and consists of two towers supporting an overhead bridge, from which a moving cradle is suspended. Passengers and vehicles are loaded on this travelling platform and ferried across the river. There are a few examples of this type still to be found in England.

From the description of the various types of bridges to be found all over the world we can see that man has shown a great deal of ingenuity in adapting his constructions to meet all kinds of peculiar circumstances. In many countries where civilization has not progressed to such an extent as here there are still many strange kinds of bridges to be found.

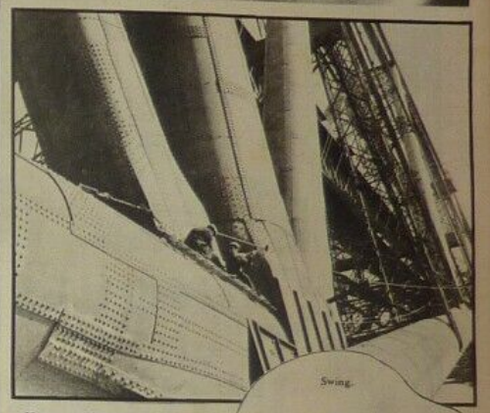
In Tibet the River Indus is still crossed by a weird kind of grass-rope suspension bridge, whilst in India there are still bridges lined with shops on either side.



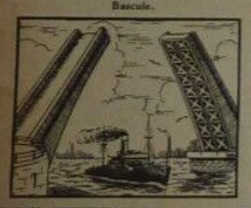
Arch Rib.



Claimed to be the longest bridge in the world, the San Francisco-Oakland Bay Bridge sweeps majestically across eight and a quarter miles of water. The mighty bridge tunnels through Yerba Buena Island and connects San Francisco with East Bay cities.



Men at work inspecting and preserving the immense steel work of the famous Forth Bridge.

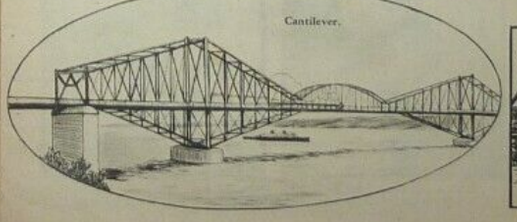


Bascule.

Single Span.

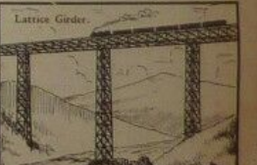
Drawbridge.

Suspension.

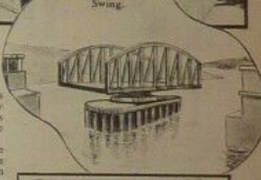


Cantilever.

Common Truss.



Lattice Girder.



Lift.

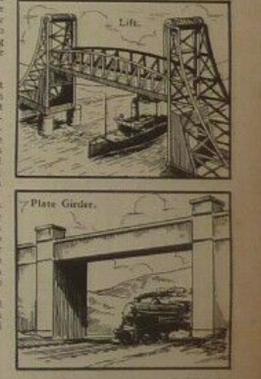


Plate Girder.

MEASURING A CONTINENT

with a Foot Rule

500,000,000 Acres of Land Resurveyed to find who really owns them

MANKIND will be less at the mercy of capricious Nature as a result of a brilliant new science of land management evolved out of the accumulated experience of the General Land Office of the United States. In fact, the Land Office was more or less forced by the catastrophic conditions of recent drought years to perfect methods of keeping human beings settled in orderly conditions in spite of natural pressures which changed, temporarily or permanently, the nature of the earth's surface.

The United States General Land Office is the only organization of its kind in the world, dealing with the land of half a continent. Russia, China, Canada, to some extent, Australia, are meeting similar problems, but the pressure on their governmental units equivalent to the United States Land Office has not yet reached the scale of that which the Americans have had to confront.

Ecological processes, involving the settling of all the world's land surfaces depend largely upon a measure of self-confidence on these surfaces. In the General Land Office, which many people believe is principally concerned with establishing definite boundaries to all sorts of public and private lands, and new and then opening certain lands to settlement, has worked out procedures by which other divisions of the government may assist people either in moving on to better lands which have gone, or in warning off areas which become exhausted or which are affected by natural geological pressures.

The aim is to prevent catastrophic tragedy due to large numbers of people being forced off lands in periods of drastic drought such as to have just passed through, and obliged to dangle over the future of the country trying to find new locations.

Handling land or forests as physical properties presents as serious problems, but handling the human factor in such organizations is another matter. But the General Land Office has solved a great segment of the problem, first, with a system of determining the accurate boundaries of all public and private lands, and, with the methods of determining the legal ownership, and, third, by a scientific system of opening lands to settlement or withdrawing lands from settlement.

The Land Office is now conducting the largest land survey ever undertaken. It involves an area of a half-billion acres.

The extent of the task is indicated by statistics which show that in the last 130 years 1,342,000,000 acres of public land have been surveyed. Almost half that number of acres, or 913,000,000 acres, of which 370,000,000 acres are in Alaska, are now to be identified and surveyed. By past standards, that would require about seventy-five years to complete!

There are now being fabricated at the Government Arsenal at Rock Island, Illinois, some 125,000 cast-iron and alloy marking posts to be used for marking the boundaries of areas to be surveyed. These markers are made of one-inch diameter tubing which will be filled with a concrete core, so that, even should the exposed portion of the marker be worn away, the buried core of concrete will still remain. These one-inch diameter tubes will mark quarter sections.

Fifty thousand of two inches in diameter, filled with concrete, will be used to mark boundaries of sections, and three inches in diameter will be used for township markers.

Two principal difficulties attend these surveys. Early surveys made during 130 years are not any too accurate and now must be fitted better into the national scheme. Old landmarks and other evidences of boundaries and titles have been obliterated through the ravages of time, particularly the wooden posts. Hence many thousands of American citizens have a real interest at stake in the correction of old surveys and the establishment of new ones.

In many parts of California, Arizona, New Mexico, and Texas, work of correcting old land measurements has been long in progress, but must now be intensified owing to the rapid settling of these States, requiring orderly and sure organization of the land ownership, to avoid thousands of lawsuit conflicts.

In Colonial Spanish and Mexican days, no difficulties were involved in measuring a parcel of land. The applicant for land made his own measurements, and no questions were asked about accuracy. Sometimes he simply guessed at the distance and asked that his grant run to a certain point. But at times the land was roughly measured.

This was done by two men on horseback, using a rope or lariat fifty yards long or 150 feet. Attached to each end of the lariat was a long pointed stake as high as the horse. One rider would set the stake, and the other rider would advance the full length of the lariat. Then the second man would put his stake to the ground and wait for the first rider to go ahead another length of the lariat. This was kept up across the land until the desired distance was attained. In trailing the rope through the water or wet grass, it would stretch, and considerable guess would be made in measuring the load. Where the grant was for several square miles of land and measured off in this way, it was very easy to add many hundreds of acres to the amount for which the grants called.

Since the grants always specified some definite acreage, when the West became more extensively populated in this modern way thousands of conflicts arose. More acres had been measured off than the grants called for, and most owners were ready to fight for what they believed was theirs, after the modern accurate surveys revealed they had appropriated too much land.

When the states became part of the United States, the Government had to recognize all private property, held in good faith, in the new territories. Most of the land property had been granted by the Spanish and Mexican governor practically free, but it was the very best land in the area.

There are still family communities in various states due to the hectic struggle to conform the granted land, in proper size and measurement, to the states' real estate set-ups. Much compromise was necessary. Some owners were simply wiped out, even though they'd lived on their lands for several generations, simply because the original grants were proved faulty or fraudulent.

The General Land Office was bedevilled up until a few years ago by off-shoots of this problem, and the Spanish grants still appear now and then as a basis for controversy in the courts.

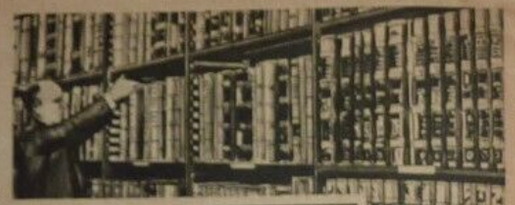
One can imagine how the present owners of valuable lands, on which their grandfathers and fathers have lived, feel when somebody comes along to claim that the original grants from a Mexican governor a century or more ago, are faulty because they lacked government sanction at the time the grant was made. Property that includes many perpetuous commodities, and which has been sub-divided into perhaps several hundred thousand parcels of real estate held by almost as many owners who feel secure, has been subjected to this kind of attack.

Designated as the official arbiter of the legality of boundary and land measurements in the United States, the Survey Service of the General Land Office is conducting operations involving both resurveys and original surveys to establish legal boundaries of land.

Through its files containing almost ten thousand volumes of tract books and more than two miles of books showing in detail the transactions in the public land by the United States since its early history, the General Land Office provides priceless records of the nation's land development.

Tracing the course of empire across the continent, land settlement was accompanied by the issuance of more than four million patents to title. Each of the documents bears the official seal of the General Land Office, affixed by an historic hand-press, still in daily use.

Who owns some of the land in several cities and states of the east and south is today just as much a problem for solution by General Land Office surveyors as it was nearly two centuries ago, survey activities and land title principles in New York, North Carolina, Arkansas, Alabama, Louisiana, and Florida being included among the hundreds of surveying operations in the current programme.



Two and a half miles of books are on file in the General Land Office at Washington. They contain priceless records of original land transactions.

American surveyors defy the rough mountainous trails in Arizona during their gigantic task.

During recent drought years thousands of squatters built homes like this on unsurveyed land and attempted to claim it for farming.

SYNTHETIC RUBBER FROM OIL

THE search for a substitute for rubber or a synthetic rubber has been going on for a long time and, according to recent reports, a certain amount of success has been met with.

It is asserted in America that, should that country's supply of rubber ever cease, a synthetic rubber made from the tremendous supplies of petroleum and natural gases could replace the rubber supply. It is reported that certain rubber technologists believe that eventually most of the world will turn to synthetic rubber in preference to natural rubber. This, it is reported, is not only because the new synthetic is cheaper by a considerable degree, but also because it is more efficient. America claims to have three formulas for synthetic rubber made from oil and its by-products already.

THE GIANT LINER UNLOADS ITSELF

ICE PATROL

SINCE the tragedy of the *Titanic* in April 1912, when that ship struck an iceberg in the North Atlantic resulting in the loss of fifteen hundred lives, the International Ice Patrol has come into existence, to prevent any such disaster occurring again.

The patrol operates nearly all the year, but with particular vigilance in the danger months, March to the end of June. It is truly international, for its ships are provided and equipped by the United States; it operates from the Canadian port of Halifax, Nova Scotia, in a wide area north-eastward from the coast of Newfoundland; and it is financed proportionately by Great Britain, 40 per cent; U.S., 18 per cent; Canada, 6 per cent; Germany, 10 per cent; the sundry smaller nations paying the balance in accordance with the provisions of the International Convention for the Safety of Life at Sea of 1929.

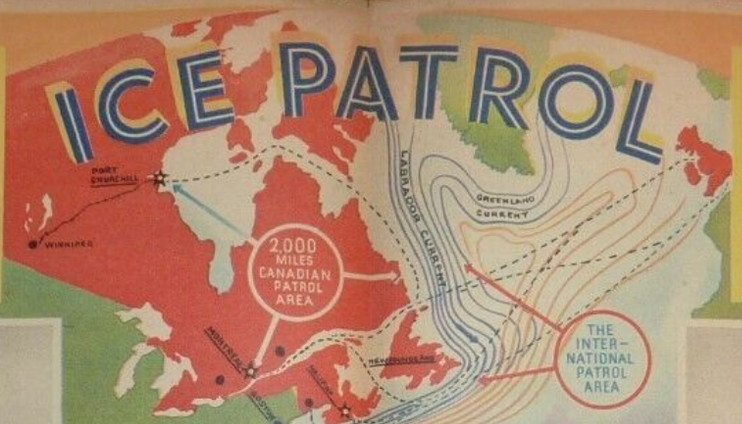
The patrol vessels and their crews perform an oftimes hazardous job or rather a multiplicity of jobs. For they have become the clearing house for information and observations to all ships in the area and to the coastguard and radio stations ashore, making reports three times a day and night—8,000 reports a season—as to exact positions of dangerous icebergs and their rate of drift, the various conditions of wind and sea, and so piling up valuable information about this most dangerous part of the North Atlantic; assisting the fishing fleet on the Newfoundland Banks as well as the palatial passenger liners on the regular sea routes.

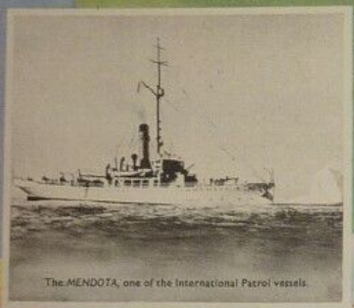
All icebergs are dangerous whether only the size of a motor car or "floating islands" 700 ft. x 400 ft., 70 ft. high out of water, with eight times as much ice under water. Usually such bergs are of fresh-water ice, solid as rock and often as dark coloured in parts, but sometimes they will be honey-combed shells only ready to collapse on anything striking their water line. These fresh-water bergs originate at the end of the tremendous glaciers of the Davis Strait and the coast of Greenland, drift out of the fiords during the summer, get frozen into the floating, drifting "ice pack" for the winter, to be released further south the following summer and carried on the Labrador current, sometimes as far south as 40 deg. N. before finally disappearing in the warm waters of the Gulf Stream. The point where these ocean currents overlap varies according to the time of the year, so that each season any number of bergs from 350 to 1,000 cross one or other of the shipping lanes, a menace to every ship, in every way.

So the ice patrol goes north and meets the first-born bergs of the season and drifts with the most southerly ones, sending out its radio and sound warnings in fair weather or foul, while the men of the patrol risk their lives frequently to speed up the disintegration of the bigger bergs. Formerly they planted high explosives in the bergs or fired naval shells into them, without a great deal of effect, strange as it may seem.

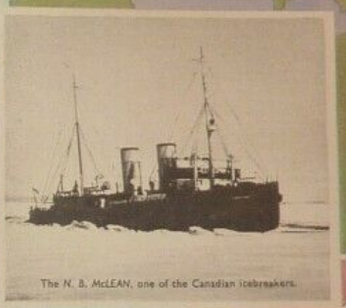
Today, they have a greater measure of success because of the invention by Professor H. T. Barnes, F.R.S., a Professor of Physics at McGill University, Canada, of the Thermit Heat Unit, which makes it possible to riddle a large part of a berg at a time with

(*Continued on page*)





The *MENDOTA*, one of the International Patrol vessels.



The *N. B. McLEAN*, one of the Canadian icebreakers.

molten metal, weakening and sometimes splitting the massive berg in all directions (in the manner illustrated) and reducing it to smaller pieces more exposed to the action of the warmer water for its final disappearance.

A dangerous job for the men of the International Ice Patrol.

For the past ten years the Canadian Government have extended their individual ice patrol out of the St. Lawrence River and Gulf and northward along the wild Labrador coast, through the Hudson Strait, into Hudson Bay to their mid-continental sea port, Port Churchill, a 2,000-mile patrol. This port is at the end of the Hudson Bay Railway which taps the farmlands of the mid-west.

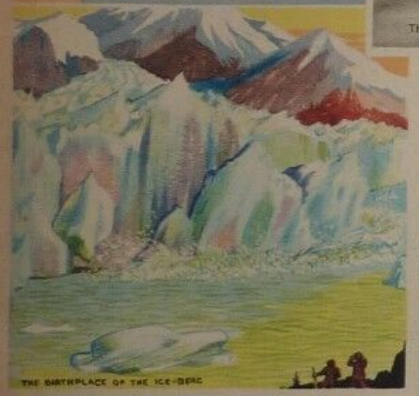
The job of the Canadian Ice Patrol is to prolong the period of open-water navigation into the St. Lawrence and Hudson Bay. Also to make continuous observations of ice conditions and their relation to the weather and the spring floods in navigable rivers, besides establishing and maintaining navigation lights, buoys and radio direction-finding stations along the route into Hudson Bay.

This needs a small fleet of steamships, lighthouse tenders, buoyships and four icebreakers. The icebreaker *N. B. McLean*, for instance, is a very powerful ship, 6,500 h.p., twin-screw, with double and reinforced hull to withstand the terrific strains of ice breaking. She is equipped with a spoon bull at the bow and exterior pressure steam jets near the water line to stay ice free; a gyro compass, radio telephone, radio telegram, sound signals, echo sounder, salvage pumps, a diver, hospital and surgeon.

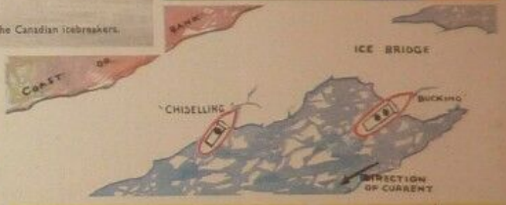
She makes frontal charges against the ice pack bow down to start a crack or bow up to slide some feet upon the ice, crash down and break through, back away and repeat. If caught between two pressing ice areas, she can roll and wriggle to rise up and slide back. An arrangement of water ballast tanks which allows water to be quickly forced from one to another plays an important part in these manoeuvres. She uses the Barnes' Thermit Heat Units as required, as do the shore crews.

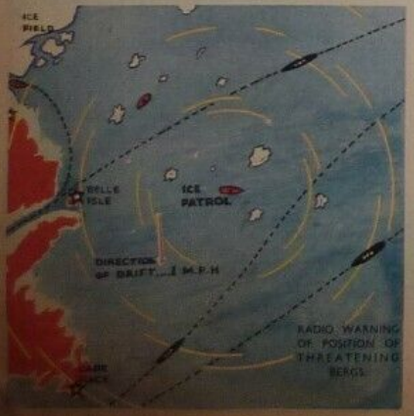
In the St. Lawrence River at certain points under the surface ice there forms what is known as frazil ice, a transparent, almost glutinous mass of ice, which, under water pressure, packs on the under side of the surface ice, building down and effectively blocking normal water flow, until the water bursts up through the surface over the top, flooding the countryside. This action is often sudden and the comparatively slow operations of the icebreakers in severe conditions cannot always cope with it. Their crews and shore men, however, working to the directions of Professor Barnes's "ice engineer," bore "shot holes" at strategic points, lower Thermit Heat Units many feet into the frazil ice, and fire them as described below (bottom centre of page). This weakened, the frazil and surface ice cannot resist the natural force of the river water and bursts through the channel, often destroying the surface ice also. The ice-breakers complete the job.

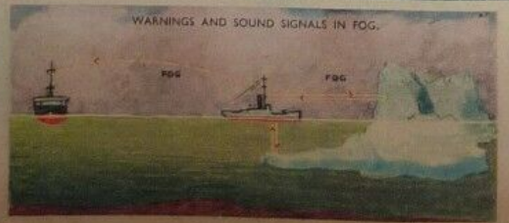
The work of the ice patrol saves losses to all kinds of business and extends by many weeks the navigable season for the river and Hudson Bay.



THE BIRTHPLACE OF THE ICE-BERG

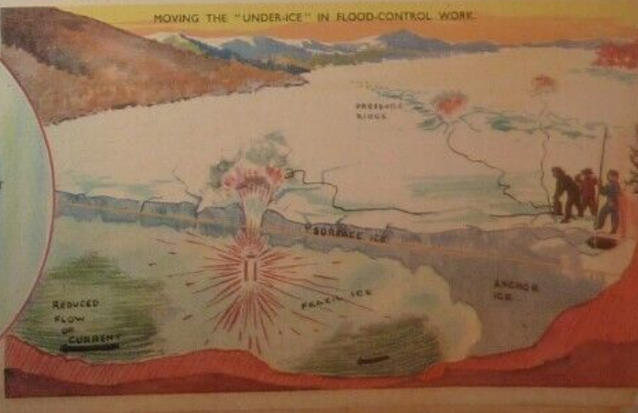






The Thermit Heat Unit is a light metal container for 160 lbs. of ordinary welding thermit, a mixture of metallic aluminium (d) and iron oxide (c), in such proportions that the combustion of the aluminium, electrically fired from a hot-shot battery (a) via the "central fire igniter" (b), results in the reduction of the oxide of iron, forming metallic iron. The heat which is thus generated raises the mass to 5,000 degs. Fahr. in five to eight seconds and the now molten iron radiating light and heat waves, runs to the bottom of the container where the shell is melted, instantly melting it to drop through the channel, instantly melting it to drop through into the ice-mass. As the piece of cast metal sets against the ice into its sudden environment, hydrogen and oxygen gas, constituent parts of water, are released and sets fire to the hydrogen gas, causing a violent explosion, projecting globules of molten iron through the ice-mass to repeat similar action several times over a period of hours, and causing speedy dispersal of floes, ice really blows itself to pieces.

MOVING THE "UNDER-ICE" IN FLOOD-CONTROL WORK



MAMMOTH POWER HOUSES – *BRITAIN'S VITAL WAR MACHINES*

HERE is the wonderful story of our electricity supply from a big power house to your home. The drawing has been simplified to show the system to advantage because the working of a big city power house is much more complicated. For instance, there would be banks of six or eight such boilers, and two or four boilers supplying steam to each turbo-generator, but we have shown only one of each.

These power stations are generally placed near a river as they require enormous supplies of cold water for circulation through the condensers, as will be seen later.

The coal hoists and cranes are a familiar sight on the river bank; here we see where that coal disappears. It enters the boiler house by a conveyer, first being crushed outside. It then passes automatically to the furnace where it is fed on to an automatic stoker. In a modern boiler house everything is spotless and perhaps you would only see one engineer walking about dressed in white overalls, keeping an eye on the gauges.

After the coal has been combusted every use is made of the resulting hot gases, not only to boil the water, but by cleverly arranged apparatus to pre-heat the incoming cold water and also to pre-heat the incoming cold air on its way to the furnace.

Superheated steam is produced in the boiler house and this passes to the turbines which drive the huge electricity generators. The current from these is collected and sent to the transformers and switch house, distributed to your local sub-station, thence to your homes.

KEY TO WORKING PARTS

FURNACE SYSTEM

1. Feed water tank
2. Coal conveyer
3. Coal bunker
4. Coal chute to stoker
5. Electric motor and gear driving stoker
6. Moving chain grate stoker
7. Hot gases and air passing through furnace
8. Feed-water heater. Hot gases pass over tubes of incoming water supply
9. Air pre-heater tubes
10. Suction discharge fan for gases from furnace
11. Furnace gases passing to chimney

AIR SYSTEM

12. Cold air inlet
13. Induction fan drawing air over pre-heater tubes
14. Heated air duct to furnace
15. Dust collector
16. Heated forced-draught air entering furnace
17. Fine ash hopper and spray
18. Clinker hopper and water spray

STEAM SYSTEM

19. Cold water supply
20. Heated feed water supply to boiler
21. Water pipe to furnace water tubes
22. Hot water rising in tubes
23. Boiler water level
24. Steam pipe to superheater
25. Superheater tubes
26. Steam stop valve
27. Double steam and water drums
28. Superheated steam pipe to turbine house

TURBINE SYSTEM

29. High pressure steam inlet
30. Rotor of high pressure turbine
31. Blades of high pressure turbine
32. Exhaust steam from high to low pressure turbines
33. Blades of low pressure turbine
34. Rotor of low pressure turbine
35. 35A. Exhaust steam outlet to condenser
36. Exhaust steam passing over cold water pipes and being condensed into distilled water
37. Water extraction pump returning water to boiler
38. Vacuum pump
39. Cold water circulating inlet pipe from river
40. Cold water circulating outlet pipe to river
41. Cold water circulating through condenser
42. Rotor of 40,000 kilowatt generator
43. D.C. cables to switch house

SWITCH HOUSE

44. D.C. from generator to transformers
45. Cable tunnel to switch house
46. Switchboard
47. Cable tunnel to local sub-stations and thence to your house

ARNHELL WOOD

ATLANTIC TRAVEL OF THE FUTURE

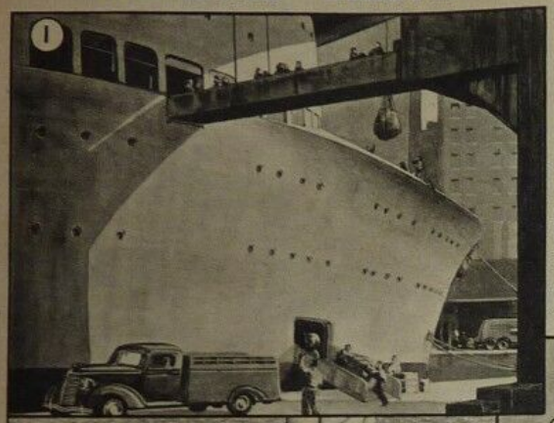
AFTER this war, as after the last, we shall in all probability see great changes in air transport. One American inventor has built a model of a trans-atlantic aircraft that would be capable of conveying 500 passengers and many tons of cargo at 200 miles per hour.

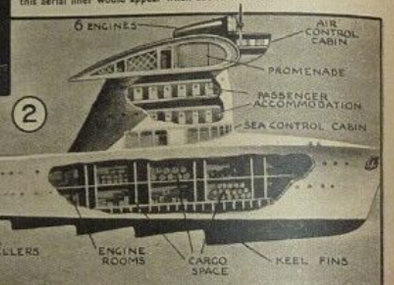
In the illustrations on this page our artist has drawn largely on his own imagination, and has endeavoured to show what this inventor's model will be like if it is built.

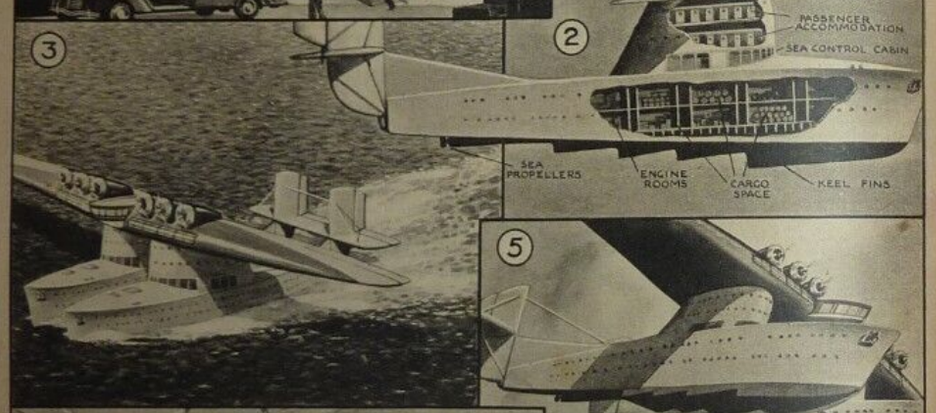
Fig. 1 shows it in dock, and gives some idea of its enormous size. Goods are being lowered into hatchways in the foredeck of one of the twin hulls, and taken in through doors level with the dockside. A gangway level with the main deck is being used to embark passengers.

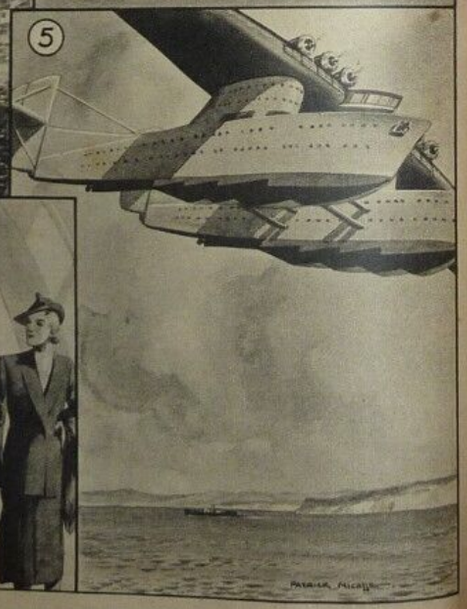
Fig. 2 shows the layout of this wonder aircraft to greater advantage. It will be seen from this that six engines are mounted in the wing. These are for use in the air, for this craft has engine rooms in the twin hulls for driving the sea propellers, which enable it to travel as a ship at a top speed of thirty knots. In the centre of the wing is a compartment for the air crew, while other members are located in the lower section of each superstructure. One very interesting part of the design is the passengers' promenade in the leading edge of the wing (Fig. 4); most of the passenger accommodation being below in the twin superstructure. Almost the whole of each hull is given over to cargo, fuel, and engine space.

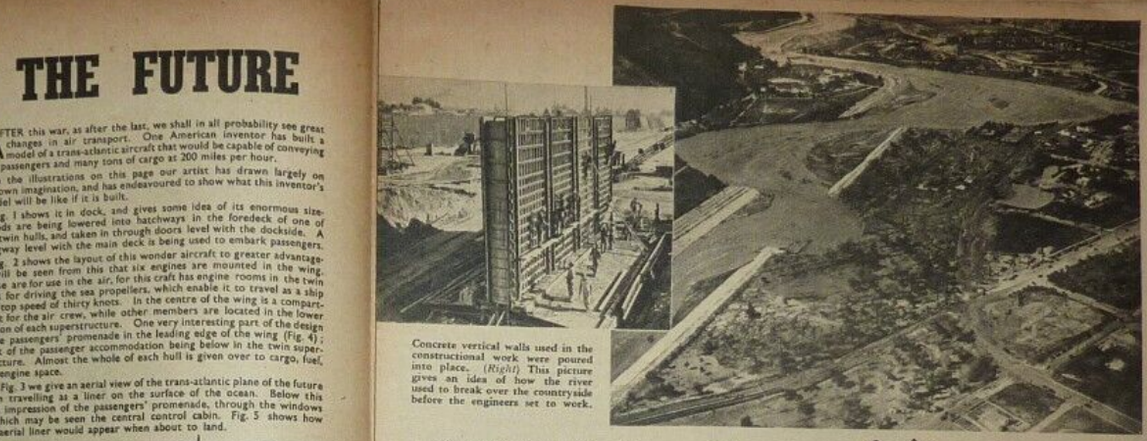
In Fig. 3 we give an aerial view of the trans-atlantic plane of the future when travelling as a liner on the surface of the ocean. Below this is an impression of the passengers' promenade, through the windows of which may be seen the central control cabin. Fig. 5 shows how this aerial liner would appear when about to land.











Concrete vertical walls used in the constructional work were poured into place. (*Right*) This picture gives an idea of how the river used to break over the countryside before the engineers set to work.

Rebuilding a River

FLOOD FIGHTERS OF AMERICA SCORE BIG VICTORY

AN unusual and somewhat novel piece of engineering work is that now being carried out in the American State of California. It is nothing less than a daring attempt to "tame" a refractory river. Engineers have been tackling the problem for some years past and a sum of £12,000,000 has been sunk in these projects.

But it has been in vain. The river has broken through the engineers' defences, flooding the country and doing incalculable damage. The river, in fact, is being rebuilt, and the cost of the new work will total £15,000,000.

The river upon which this colossal sum is being spent is only seventy miles in length and for the greater part of the year is little more than a dry bed. To grasp something of the character of the stream and the difficulties which face the engineers one has to remember the topographical features of the region. The stream in question is the Los Angeles River, named after the city of that name through which it flows.

Los Angeles is the capital of Southern California and has a population of 1,500,000. During heavy rains in the winter months the river is subject to floods. In a flood so recently as 1938, the down town portion of Los Angeles was submerged to a depth of over six feet. Sixty persons were drowned and the damage done to property totalled several million dollars.

The river rises in the San Gabriel Mountains, a portion of the Sierra Madre range. The elevation of the range is over seven thousand feet. For forty miles the stream rushes down through steep mountainous country till it reaches the plain, finally emptying itself in the Pacific Ocean. The fall in the first forty miles equals that of the Mississippi River between Omaha, Nebraska, and the Gulf of Mexico.

Then the river is fed by many tributaries, eighteen in all, as well as by arroyos and washes from the mountain slopes. The torrential rains of winter transform the river and its tributaries into raging torrents which bring down soil, gravel and boulders, often scouring new channels and flooding the lowlands. The impetus and fierceness of these floods can be likened to that of the discharge of a bursting dam.

How best to control this erratic river has presented varied problems. The task is being carried out by two groups of engineers working in close collaboration, United States Army Engineers under the supervision of Major T. Wyman, assisted by engineers of the Los Angeles Country Flood Control. Quite apart from Los Angeles River itself it was necessary to pay attention to its tributaries. These tributaries, too, supplied water for irrigation and stock raising.

These supplies could not be interfered with. Indeed the scheme was to enlarge them and thus increase the area of settlement. Accordingly attention was first paid to the streams in the foothill areas. Here some hundred basins and dams have been constructed to trap water-borne debris and to check water travelling at high velocities. Channels have been constructed to control water flowing from these basins.

Below the foothills and on the coastal plain channels have been enlarged straightened, and provided with bank protection, or enclosed within reinforced concrete channels. The engineers have solved the problem of flood control in low-lying areas by providing more efficient drainage into the ocean, or by installing pumping works, to raise the storm water to elevations where it will most conveniently drain off.

More important and far more difficult to carry out is the work now proceeding in connexion with Los Angeles River itself, particularly that section of the stream which flows through Los Angeles. While bone dry in summer, the river is called upon to carry water at the rate of 90,000 cubic feet a second through the down town portion of the city during a winter flood. To save this congested area from floods various forms of work are being undertaken—straightening, widening and deepening of the bed of the stream.

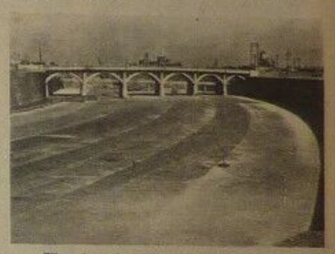
Were you to follow the river from its headwaters you would first come upon an excavated trapezoidal earth channel for 5.3 miles above the junction with Tujungs Wash; a concrete and rock paved channel from this wash 6.6 miles to the junction with Verdugo Wash; and a trapezoidal channel with concrete slab or grouted rock bank protection from about this point 6.8 miles to Dayton Avenue, Los Angeles, with special concrete section at the inlet of Verdugo Wash. A trapezoidal, it may be added, is a four sided construction whose sides are neither equal nor parallel.

From Dayton Avenue, the channel traverses the congested business and industrial districts of Los Angeles for a distance of five miles. Due to limited rights of way available and the proximity of main-line railways on each side, channel dimensions vary throughout the reach. At some points the channel must be deepened, with consequent faster stream flow.

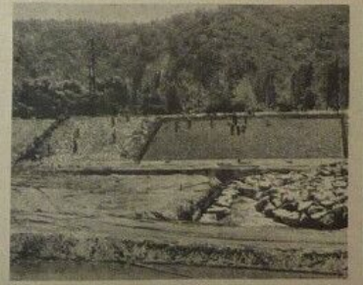
In brief, this will be a man-made, or rather re-made by man, stream whose destructive power is very great indeed. In the heart of the congested area the stream drops 310 feet in thirteen miles, or twenty-four times faster than the Mississippi. The old channel was rough and full of bends. Its bottom is being smoothed, bends being removed through a costly straightening process.

On account of a mountain in Elysian Park, railways, utilities and expensive properties elsewhere, it cannot be widened economically. Therefore, the engineers resort to a variety of expedients designed to handle maximum anticipated flood flows. Following the flood of 1938, one million cubic yards of earth was removed in a reach no longer than four miles. The channel, when completed, will have a carrying capacity of 70,000 to 109,500 cubic feet of water per second.

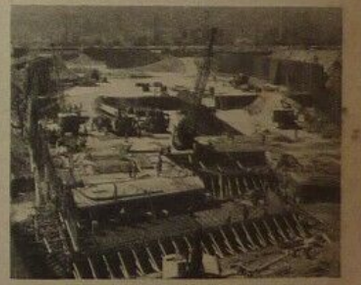
From many points of view, rebuilding this fractious stream presents engineering novelty. It is only part of a larger programme, however, that of saving both life and property over a wide area of Southern California. How well the engineers have built this wonderful river bed only time and flood can tell.



When the engineers had completed their work they had prepared a channel which flood should not affect. This is how part of the new river bed looked when finished.



The banks of the river are in parts rock pavement, and on the right of picture can be seen reinforced concrete slab which further along gives place to vertical concrete walls.



Where Verdugo Wash joins the Los Angeles River the transition is made by means of a settling basin, baffles, and a training wall which extends into the channel of the river.

Continuing

CAMERA RAIDERS OVER GERMANY

about sixty pounds less than its German counterpart. Both are compact and virtually foolproof; they are designed to work in the worst circumstances and require very little attention. One is completely automatic, and contains an interchangeable magazine, big enough to give 125 exposures. The magazines can be changed in the air in a few seconds.

In the dawn at the start of a flight, a van crosses the aerodrome to the waiting bomber. Cameras and drums of ammunition are transferred to the aircraft, and the vertical camera is screwed into place; the oblique camera is held in the hands and is placed ready in the fuselage. The vertical camera is set before the flight begins, according to the probable visibility and flying altitude. Service is so efficient that the setting rarely proves unsuitable, and should there be an error, it is so small that it is easily corrected while the films are being processed.

Meanwhile, the first pilot has started the engines, and the crew have come aboard. Each knows the others' work and has been trained to co-operate. The aircraft takes off for Germany. The purpose of this particular flight is, let us say, to obtain information of certain enemy aerodromes, and on approaching the first objective, the pilot takes the aircraft down through the cloudbank, sees on the left the circle of hangars, and swings the machine towards it.

A straight and level course, which is necessary for good aerial photography—though it makes gunfire from ground defences more dangerous—is set over the middle of the aerodrome, the cameras are started, and after photographing twenty or thirty German aircraft lined up 2,000 feet below, the aircraft goes on to its next objective. No notice has been taken of the solitary raider.

It is not until the R.A.F. machine reaches the third aerodrome that it encounters opposition. Most of the necessary photographs have been taken, however, before the enemy fighters dive down on the raider from behind. Our air gunners hold their fire until the enemy are close, and in the meantime the British aircraft keeps on its course until the camera has finished its task. Only then does our aircraft slip upwards into the clouds.

At the final aerodrome on the list it is necessary to drop to 1,000 feet in order to make sure of getting good results, and the observer now uses the oblique camera. Pom-poms and machine guns fire at the intruder, but it is off again before any damage can be done.

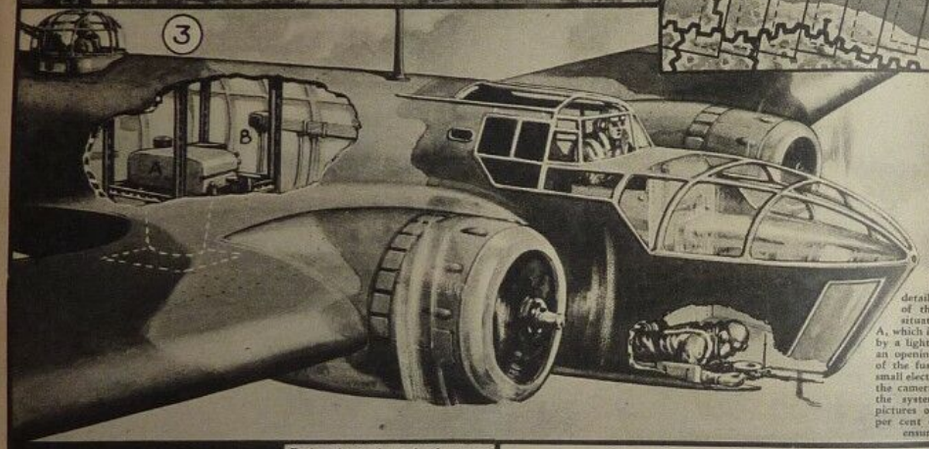
At home, the magazines are removed for developing and printing, the observer makes his report, and in two or three hours the prints are being inspected by experts. Stereoscope and magnifiers tell them much that was unseen even by the trained observer in the aircraft; types of craft will be recognised and activity noted.

Such was a typical instance of R.A.F. activity in this connexion. Sometimes it is less straightforward, and photographs may have to be taken from as low as 500 feet or as high as 24,0000 feet.

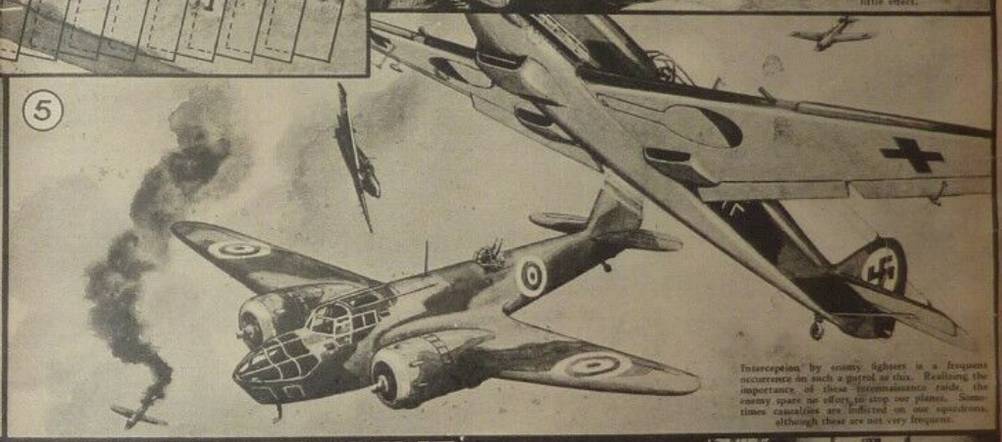
1 The long-nosed "Blenheim" reconnaissance plane takes off from the aerodrome at the start of the camera patrol. The plane carries a heavy automatic camera in place of the usual bomb load.

2 Crossing the German lines into enemy territory, the plane is almost certain to be attacked by anti-aircraft fire. But owing to the inaccuracy of the gunfire and the quality of the planes this has little effect.

4

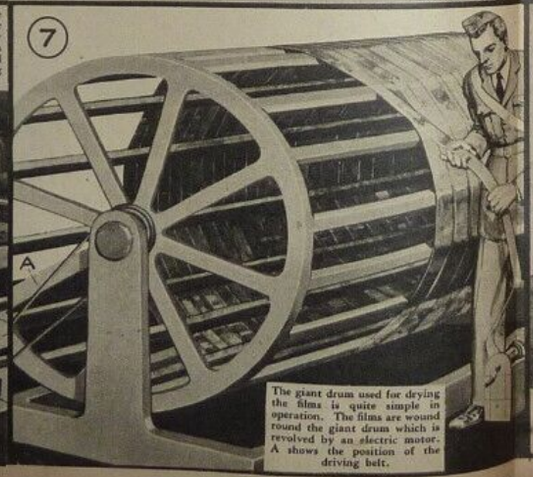


3 A close-up view of the reconnaissance aircraft showing internal detail. Just forward of the gun turret is situated the camera, A, which is held in position by a light framework over an opening in the bottom of the fuselage. B is the small electric motor driving the camera. Fig. 4 shows the system whereby the pictures overlap about 60 per cent of their area to ensure accuracy.

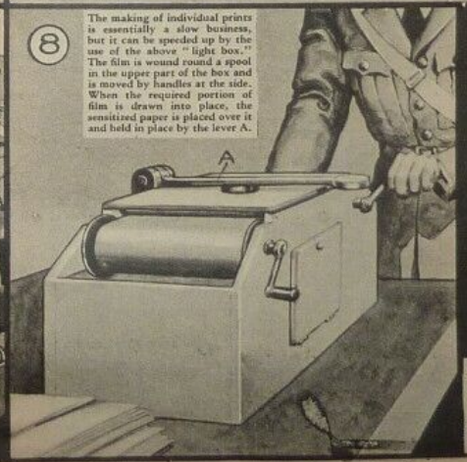


5 "Intercepted" by enemy fighters is a frequent occurrence on such a patrol as this. Realizing the importance of these reconnaissance raids, the enemy spare no effort to stop our planes. Sometimes casualties are inflicted on our squadrons, although these are not very frequent.

6 Back at the aerodrome the pictures are immediately developed, a job for which the R.A.F. employs many skilled photographers. First the film is placed in the soaking tank A, and subsequently in the developing fixing and washing tanks B, C and D.



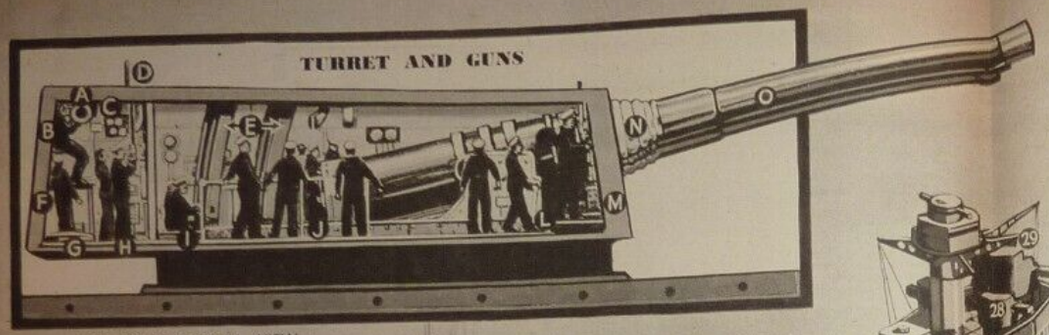
7 The giant drum used for drying the films is quite simple in operation. The films are wound round the giant drum which is revolved by an electric motor. A shows the position of the driving belt.



8 The making of individual prints is essentially a slow business, but it can be speeded up by the use of the above "light box." The film is wound round a spool in the upper part of the box and is moved by handles at the side. When the required portion of film is drawn into place, the sensitized paper is placed over it and held in place by the lever A.

9 As soon as the prints are available the pilot and other members of the air crew are interrogated to gain information on the photographs and data which might otherwise lapse from their memory.

AN ARMED GIANT of the ROYAL NAVY



KEY TO TURRET AND GUNS

A. Range finder
B. Range taker
C. Control cabinet
D. Periscope
E. Guides of loading cage
F. Messenger
G. Entrance
H. Turret officer
I. Loading cage rammer lever men
J. Guns' crews
L. Elevating control
M. 16-inch armour
N. Blast bag
O. Three 16-inch guns

The shells weigh 2,461 pounds and the cost of firing a triple salvo is £700. The guns have an elevation of 40 degrees and a range of 35,000 yards.

KEY TO SECTIONAL VIEW

UPPER DECK AND SUPERSTRUCTURE

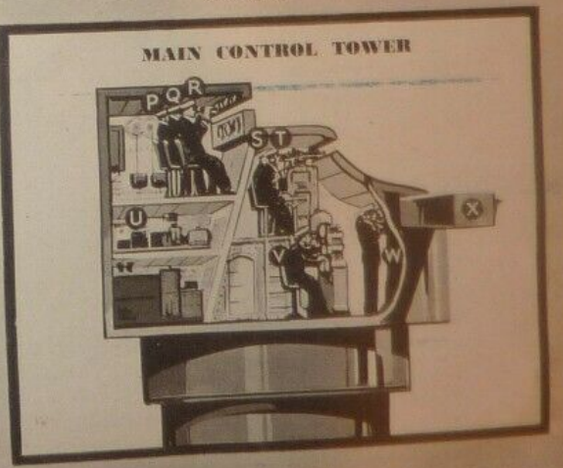
1. Ensign
2. Quarter deck
3. Lifebuoys (automatically released from bridge)
4. Two after 4.7-inch high angle anti-aircraft guns
5. After control tower
6. Paravane
7. Saluting gun
8. and 8a. Secondary armament after control towers
9. and 9a. 36-inch searchlights
10. Mainmast
11. Helm signal indicator
12. Signal yard
13. Speed boat
14. Boats
15. Steam pinnace
16. Multiple pom-poms
17. 17a and 17b. Starboard 6-inch secondary armament
18. Searchlights
19. Carley floats
20. and 20a. Range finder towers
21. Vents
22. 4.7-inch high-angle anti-aircraft gun
23. Multiple pom-poms
24. Bakery
25. Bread cooling rooms
26. Starboard lifeboats
27. Control tower and bridges, sea cabins, etc.
28. Secondary armament director towers
29. Main director tower
30. Conning tower
31. "X" turret and three 16-inch guns
32. "B" turret and three 16-inch guns (superimposed)
33. "A" turret and three 16-inch guns
34. Breakwater
35. Capstans
36. Anchor cables
37. Starboard anchors
38. Jackstaff

BELOW DECKS

39. Admiral's dining cabin
40. Admiral's sleeping cabin
41. Captain's cabin
42. Captain's sleeping cabin
43. Officers' quarters
44. Baths
45. Turret support
46. Baths
47. Officers' quarters
48. Warrant officers' quarters
49. Marines' reading room
50. Wash place
51. Marines' mess
52. Marines' sergeants' mess
53. Boys' mess
54. Stokers' mess
55. Petty officers' mess
56. Reading room
57. Hospital
58. Operating theatre
59. Officers' quarters
60. Church
61. Baths
62. Turret support
63. Main wireless room
64. 64a and 64b. Lobbies
65. Wash places
66. Reading room
67. Seamen's mess
68. Ditto
69. Oilskins' room
70. Seamen's mess
71. Shipwrights' store
72. Officers' quarters
73. Working space
74. Gun room stores
75. Receiving room
76. Chronometer room
77. After starboard boiler room
78. Forward starboard boiler room
79. After turbine engine rooms
80. Forward turbine engine room. (Note that in these ships the engines are placed forward of the boilers)
81. Auxiliary wireless room

KEY TO MAIN CONTROL TOWER 30 FEET ABOVE THE SEA

P. Assistant control officer
Q. Observer of fall of shot
R. Principal control officer
S. Director layer
T. Director trainer
U. Expansion tank machinery
V. Director sight setter
W. Range taker
X. Range finder



Continuing KEY TO SECTIONAL VIEW

82. Stores
83. Armature room
84. Store rooms
85. Canteen store
86. Medical stores
87. Flour stores
88. Awning room
89. Band room
90. Lower conning tower
91. Side of ship
92. to 92J. Watertight transverse bulkheads
93. Starboard propeller
94. Rudder

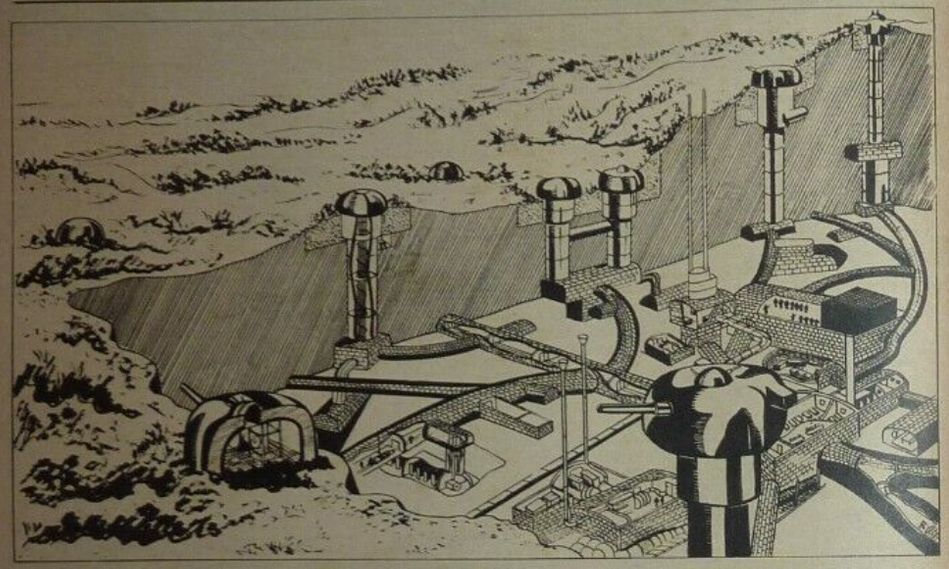
The mighty fighting ship pictured on these pages represents the two battleships* H.M.S. Nelson and H.M.S. Rodney. Sister ships, Nelson has a displacement of 33,500 tons, that of Rodney being 33,900 tons, and each cost over £6,000,000 to construct.

These floating fortresses are 710 feet in length with a beam of 100 feet and a mean draught of 30 feet, and their mighty 45,000 h.p. engines enable them to steam at 23 knots an hour. Their complement as flagships is 1,361 officers and men, and their armaments include nine 16-inch guns, 4.7-inch high-angle anti-aircraft guns, and 6-in. guns and multiple pom-poms.

IT STANDS IMPREGNABLE AGAINST THE MOST SAVAGE ONSLAUGHT OF MODERN WEAPONS . . .

THIS MIGHTY MAGINOT LINE!

By BERNARD HOGBEN



TWENTY-FIVE years ago a French private stared out over the shell-shattered fields of Lorraine. He saw his beloved country overrun by the German invader, and during the four years that followed he built up in his mind a defence that would free his people from the ravaging hosts, and make the desolation of the present impossible for future generations of Frenchmen.

His dream was the European line of defence of which we read every day—the mighty Maginot Line. Though a mere private in the ranks of the French Army, who afterwards won the rank of sergeant, Andre Maginot was in a position to put his dreams into practice. Before joining up in the ranks he had been an Under-Secretary for War, and after receiving a leg wound in 1916 he had to retire from active service. Returning to civil life he took up various ministerial appointments, and at last was rewarded with the job upon which his heart was set, the Minister for War.

The chance to put his vision into effect had come to pass. His was the broad conception: the technical details were left to others. But meanwhile the imagination of the people of France had been gripped with the colossal idea of such an impregnable line of fortresses. Public opinion was behind this vast construction work, and careful, unhurried work was carried on for many years so that the Line might provide a bulwark against the most savage onslaught of modern weapons.

Maginot did not live to see the result of his work. But he had started on a defence scheme which was to prove never-ending. To keep it up to date with the latest methods of offensive warfare, work on the Line never ceases. All the time technicians incorporate new ideas in the fortifications.

The line of defence which separates the peoples of France from those of Germany consists of vast fortresses, buried deep down below the surface of an apparently undefended countryside. Connecting these together are miles and miles of underground

Men trained in the use of all the latest modern weapons enter the tunnels that lead to the vast underground maze of the Maginot Line. These steel and concrete constructed tunnels allow room for troops to march and vehicles to pass along.

Giant Diesel engines are used to supply electricity to the underground forts. Lifts, gun-turrets and trains are all supplied with current from the power stations below the ground, and are independent of outside supplies.

Telephones play a big part in the direction of operations underground. The artillery officer seen at his post is able to direct the fire of mighty guns that belch forth their deadly fury on the enemy.

Electric trains transport troops over hundreds of miles of underground lines.

tunnels, riddling the earth with passages that link up observation posts, gun turrets, and all kinds of devices which tell the defenders of the approach of an enemy.

All the latest scientific developments are included in the construction of this, the most formidable and impregnable line of defence. Above the surface empty houses and harmless-looking woodland glades house the "eyes and ears" of the vast army working below the surface. Infra-red rays and all the latest alarm signals ensure that the French defenders can never be taken by surprise.

Somewhere in the forests of France stand huge iron doors. Only those on official business can ever get near them, but through this gateway pass the men, on their way to safeguard the frontiers of their country. Along a rapidly descending tunnel they pass until they come to lifts which carry them deep down into the bowels of the earth.

When the lift reaches the bottom the men get into the cars of an electric railway which carry them from one part of this tremendous underground maze to the other. Lower levels of the tunnels are reached by more lifts, and in this amazing underground city hundreds of thousands of officers and men live and work in a high standard of comfort.

Beneath the solid earth great Diesel engines drive the alternators which supply all the electricity to the forts. Doors to all the forts and sleeping and living compartments have rubber edges so that gas attacks hold no fears for these soldiers who burrow into the ground like moles.

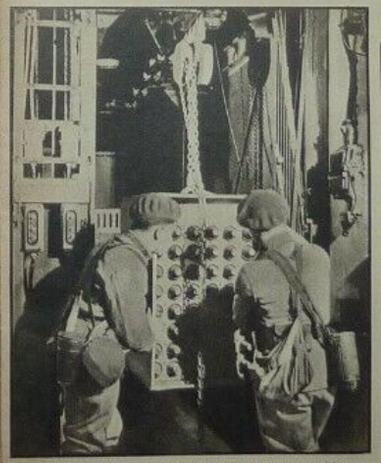
Seven two-hundred-mile galleries of steel and concrete lie below the flowering fields of France; each playing a definite part in this greatest defensive construction the world has ever seen. From the Belgian frontier to the start of the Swiss, this network of tunnels stretches in unbroken line.

Electrical machinery is installed at vital points which enables the air pressure to be raised so that poison gas cannot enter. In the barracks men and officers live in comfortable mess rooms, where food comes from the most up-to-date labour-saving kitchens. Wireless, cards and other forms of amusement are provided, and modern bathrooms and comfortable beds all compensate the troops for their life underground.

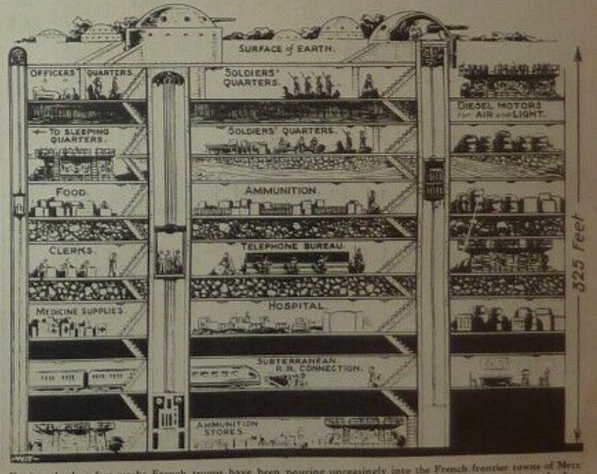
The domed concrete gun-turrets that raise their heads at intervals along the surface of the frontier, command the ground that leads on to French soil, but if they were the only defence or purpose of the Maginot Line the French people might not have the same confidence in the solidity of their bulwark. Walking through the countryside above the underground line a casual observer would think that everything was peaceful, and that an advancing army would meet with little resistance.

But there in the quiet country lanes are unseen watchers. Sentries whose job it is to notify the first sign of an attacking force. The harmless-looking hedges hide their nests of machine guns, the undergrowth conceals traps which will immobilise the giant mechanical monsters of the enemy.

Beneath the surface men spring to life at the first alarm. On cycles they rush along the tunnels to their posts. In a surprisingly short time guns are manned, and France's wonderful defence line stands to attention to give the foe a surprise which he is not likely to forget.



Shells to feed the guns are drawn from the ammunition stores deep underground. They pass on their way on the conveyers seen in the picture.



During the last few weeks French troops have been pouring unceasingly into the French frontier towns of Metz and Strasbourg on the Maginot Line, all prepared to man vast subterranean forts stretching in an unbroken line of steel and concrete from Flanders to Switzerland. This is a sectional drawing of this impregnable defence.

WILL WE LIVE IN UNDERGROUND CITIES?

ALL OVER THE WORLD SCIENTISTS ARE DESIGNING UNDERGROUND CITIES FOR PEACE AND WAR

MOST of the pictures that imaginative artists draw of cities of A.D. 2000 or 3000 show giant towers a half-mile or so tall, lacy highways and bridges of strung steel connecting these, hundreds of aeroplanes or helicopters coming and going from aerial landing fields thousands of feet above the ground.

Maybe so, but there is at least one outstanding expert in city planning who believes—or fears—that it will be nothing of the sort. A few weeks ago there met in the City of Mexico an International Housing and Town Planning Congress attended by nearly five hundred representatives of governmental and other housing organizations in more than a score of countries. To them Mr. E. J. Goodacre of the British delegation presented the view that future builders must attempt to burrow instead of fly.

Underground, not overhead, is where mankind is condemned, Mr. Goodacre fears, to spend the next few centuries. War from the air is what will force this. Underground regions are the only safe refuges from modern bombs and fire-makers and poison gases rained down from the skies. Science has brought these, and now science must protect the cities from them by devising the new cave-man way of life.

Whether or not the citizens of the future are going to like living underground has nothing to do with it, any more than whether bees like living in a beehive or ants in an anthill.

According to Mr. Goodacre, the future city will be a double one. Above ground will be some of the buildings, many peace-time dwellings, a few parks, and recreation grounds and the like. Underground will be refuges for the entire population, not merely for a few hours during a raid but for many days or even weeks. So far as possible, the underground parts of the new city will be used in peace as well as war. Railways and other highways for traffic will be subterranean.

In wartime they will be refuges. Garages will be planned similarly. And there will be enough basement and sub-basement space everywhere for the whole population in case of need.

Walking over the countryside near the French and German underground fortifications one might not even realize that anything existed except woods and farms. Here and there are curious-looking low domes or other objects made of concrete.

On the German side of the frontier one sees rows of concrete pyramids, looking not unlike an overgrown and too-monotonous cemetery, but which really are entanglements intended to stop the advance of tanks. The real marvels, however, are underground, just as Mr. Goodacre believes cities will be.

Inside the French line, whole hills have been hollowed out for galleries to hold the guns, firing through narrow concrete slits, or for the barracks, dining-rooms and living quarters of the hundreds of thousands of troops. Complete underground railways will haul up supplies and haul back wounded if shells do break through.

Complete duplicate or triplicate telephone systems provide for communication. Complete electric power plants will keep the underground war machine going in case power from behind the lines is cut off. Thousands of men could live in one of these underground war cities for months.

Recently it was reported that German artillery had been practising on the similar underground defence lines built by Czecho-Slovakia. How well the underground fortifications stood the ordeal the German experts probably will not disclose, but facts learned are sure to be embodied in German plans for whole underground cities, if not in similar plans of other countries.

Other valuable experience for city planners who agree with Mr. Goodacre is being accumulated in the Spanish city of Barcelona, which is reported to have been bombed by more than two thousand separate air raids during the present civil war.

A few weeks ago a British engineer, Mr. Cyril Helsby, spent some days in Barcelona studying the engineering features of the bombardments, came back to London and reported his observations to the Institute of Structural Engineers.

In many places in the city tunnels have been dug, slanting down from the street to a level about forty-five feet underground. These open into passages underneath the buildings, midway between their front and rear, and running around the whole block. At intervals, larger rooms are hollowed out to accommodate more people.

Other tunnels running through the blocks like the arms of a cross provide safety connexions in case some tunnels are blocked or collapse. Multiple entries and exits are provided for similar reasons, and so that scarcely anywhere in the crowded parts of the city is a pedestrian more than five hundred feet from an entry into which he can dive in a few seconds when an alarm is sounded.

All of Barcelona's official shelters have electric lights, supplied by underground connexions to the power lines. In addition, there are racks of electric storage batteries in each, connected to emergency lights and kept charged by a trickle-charge connexion to the power lines.

Running water is supplied underground, together with drainage and toilet facilities. Some shelters are provided with stores of food and simple kitchens for cooking it. All have complete sets of first-aid materials and of digging tools, so that the occupants can dig themselves out in the unlikely event of all of the multiple exits being blocked.

In the new underground plan for whole cities, Mr. Goodacre and others who agree with him plan for much more attention to the pleasures of being alive, as well as merely staying that way.

One device of the underground city will be the sun tower, projecting through the upper bomb-proof levels of concrete and steel and providing both a way for people to get up and see some sun if they have time and everything is safe, and also for sunlight to be sent down into special sun parlours far below.

Astronomers already have sun telescopes with one lens or mirror up on a tower and other lenses and the cameras set in underground chambers far below.

Automatic machinery moves the upper lens or mirror so that the sunlight is caught always at just the right angle and sent down the shaft into the underground camera room, no matter what time of day it may be above. In the future city, similar but larger towers are planned, to catch much larger quantities of sunlight and reflect it below.

By means of tubes or rods of pure quartz or of one of the new transparent chemical plastics, it even will be possible to "pipe" the sunlight from place to place below, providing, perhaps, sunlit clinics, nurseries or recreation gardens hundreds of feet underground.

People who want to see what is going on above ground need not risk their lives or weary their muscles climbing out to look. There will be giant periscopes, to show the entire above-ground view to any one who wants to take a look, or perhaps a series of television screens to do the same. Even on the basis of present perfection of television, this would be entirely possible.

If for any reason real sunlight were difficult to provide, or if the underground dwellers happened to want some when it was cloudy above ground and no real sunlight could be caught, there now are artificial sunlamps which could be provided in every underground home or office willing to pay the small additional charge.

Finally, among the advantageous ideas which Mr. Goodacre expects to balance science's contributions to destructiveness, are the modern chemical plants, not to get fresh air but to make it unnecessary.

The modern underground city need never fear a stoppage of its air supply or that the enemy might be able to poison the air sucked in at the intakes. There would be no intakes.

Instead, the whole city could be sealed tight and the air inside made to last virtually for ever, by means of chemical and electric apparatus to recondition this air continually for human or animal use. Small examples of such apparatus already are in use or have been tested for undersea divers and submarines.

No one expects great present cities such as New York or London instantly to turn buildings upside down and begin to burrow underground. The underground city will be a gradual growth, perhaps a fast one if war comes. But there are some steps which Mr. Goodacre, Mr. Helsby and their supporters believe can be begun at once, and should be.

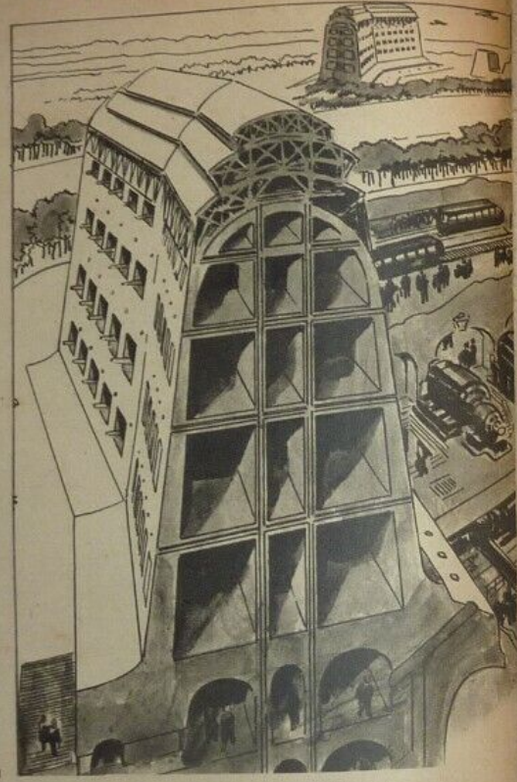
Already the majority of cities in the world are puzzled how to care for traffic on their streets. Most streets have their capacity for carrying traffic cut down greatly by parking of cars. Gradually this is being prohibited anyway, and cars stopped for more than a few minutes forced into garages. The trouble is to provide enough garages close enough to where most people want to stop.

The suggested solution is vast garages underneath every building in the congested part of any city.

Another immediate step, already reported to have been planned during construction of the Moscow Subway, in Russia, is use of all such underground transportation tubes for similar refuges.

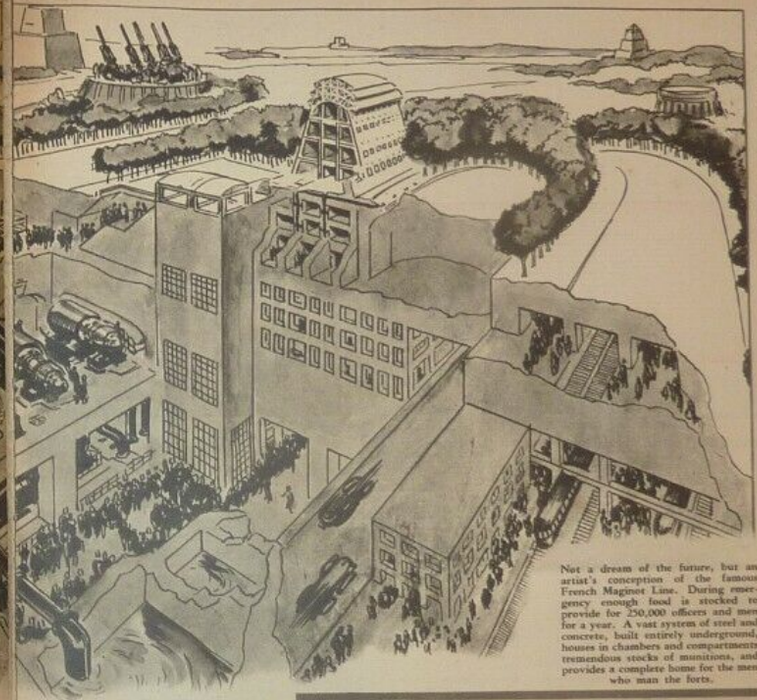
Russian engineers, indeed, long ago designed the complete underground city illustrated on this page, and no one knows how much of this has been built, secretly and without foreign publicity. One suggestion for other countries is that all subways constructed from now on be made wider and deeper, or both, and the extra space fitted up at once for hospitals and dressing stations.

In peacetime, these suite rooms could be used as ambulance stations, receiving hospitals for sick or injured or rooms for the many kinds of health clinics that most cities now maintain. Thus a considerable part of a city's health and medical services could move underground immediately, reduce present congestion above ground and provide immediate and continual practice in the hospital duties which war raids would make necessary.

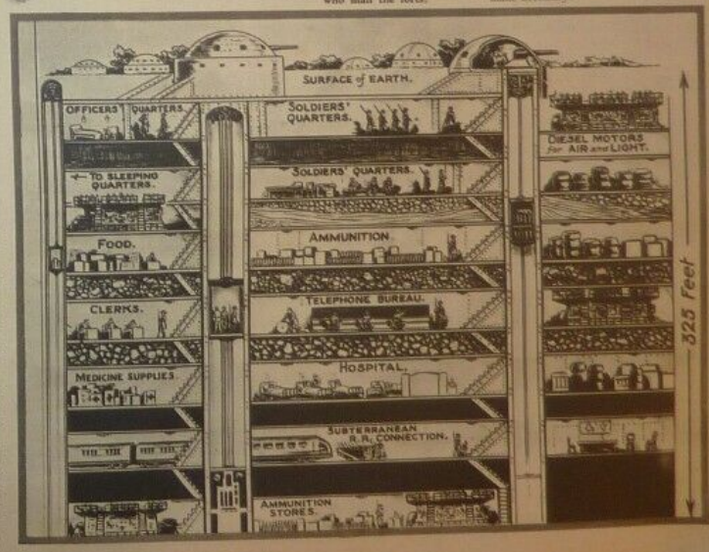


(*Left above*) **A city of the future, built deep underground, with synthetic sunlight permitting natural plant life.**

(*Above*) **A pictorial diagram of an underground city planned by Soviet engineers. Lighting, transport and all other utilities are provided to make a self-contained safety zone for the civilian population.**



Not a dream of the future, but an artist's conception of the famous French Maginot Line. During emergency enough food is stocked to provide for 250,000 officers and men for a year. A vast system of steel and concrete, built entirely underground, houses in chambers and compartments tremendous stocks of munitions, and provides a complete home for the men who man the forts.



Beneath Arctic Ice to the Pole!

THE WILKINS-ELLSWORTH SUBMARINE EXPEDITION

Four of the leading associates of the expedition:
1. Captain Sir Hubert Wilkins, the high-principled, world-renowned, Australian-born explorer.
2. Lincoln Ellsworth, distinguished explorer and aviator, associate of Amundsen and Nobile.
3. Simon Lake, naval architect and inventor of submarines.
4. Sloan Farrenhower, submarine and salvage engineer, son of an explorer.

THE objective of the Wilkins-Ellsworth Submarine Expedition is not limited to reaching the Pole by submarine and returning safely. It is to prove that what is generally considered impossible and impractical, to be definitely possible and sanely practical with results of tremendous benefit to the scientist and ordinary man. It is to prove the means by which man may exist comfortably (comparatively) in the Arctic or Antarctic regions for sufficient time for continuous study of meteorological, aeronautical, oceanographic and geodetic problems, which certainly do have a bearing in some way on every individual's existence and livelihood.

Captain Wilkins's own life of exploration was and is motivated by the desire to discover and combat the real cause of disastrous droughts in the Australian interior, and it leads him to the Antarctic first and will bring him back there again. His tremendously valuable work in the north, however, he regards as a prelude to the advance on the Antarctic to come. Also he finds greater financial co-operation and interest by nations of the north in the Arctic rather than the Antarctic.

The idea of using submarines was put forward by Stefansson, a Canadian Arctic explorer, during 1913-18 when Captain Wilkins was a subordinate member of his expeditions. This gradually developed in Wilkins's mind, till he, some years later, announced future intentions to use a submarine and commenced the necessary research, experiments and tests. In the course of these, Captain Wilkins made an extremely interesting discovery of the fact, among other things, that the idea of using a submarine for Arctic exploration was first suggested 290 years ago (1648) by the clergyman founder of the Royal Society of London; that this was long before submarines were invented; and that the author was the Rev. J. Wilkins, a bishop, and proved ancestor of the present Captain Sir Hubert Wilkins.

Stefansson, the Canadian explorer, has said, in effect, that it was feasible for a submarine to navigate safely from Spitsbergen to Alaska, at depths ranging down to 250 ft. approximately, to avoid big jagged snags (or peaks) of ice.

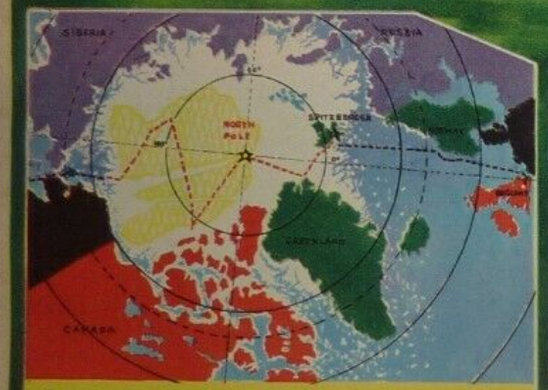
Since then, Captain Wilkins has definitely ascertained that the expedition will seldom find ice more than 50 ft. below the surface, but that over the greater part of the Arctic Sea the ice will average about 14 ft. thick and raggedly level on the under side. The records of his own and all other expeditions and flights establish the fact that even in winter, there is no continuous unbroken thick layer of ice over the Arctic Sea and that 20 per cent is open water; that from Europe to Alaska and quite close to the Pole, open water "leads" are constantly appearing.

Since 1931 the expedition personnel have made several preliminary trips and done much research work, with a modern ex-naval submarine, donated by the U.S. Government, and structurally adapted by the expedition for under-ice work.

This submarine is 175 ft. long, twin screw, submerged speed over nine knots and on surface fourteen knots, submerged tonnage 550, and on surface 425, tons. It has a safe range on fuel of 7,000 miles; on batteries, 100 miles at four knots for thirty hours (and eight hours is the most expected to be necessary). It can carry six months' food and twelve months' emergency rations for scientists and crew to do a trans-Arctic exploring journey of 2,100 miles in about six weeks; several helium gas balloons to carry up instruments; twin divers and equipment plus an under-water movie camera; Wilmesz gravity-measuring apparatus; broadcasting radio.

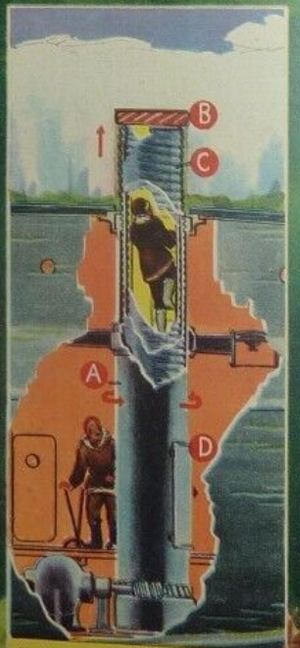
Other features shown in the artist's impression on the upper left are: A, a periscope "sled"; deck; m, frequent contact with ice; E, elevator; F, guide arm in elevated position; C, hydraulic buffer; D, powerful bow lights; E, telescopic steering tower, with boring attachment; F, telescopic air intake tube, with boring attachment; G, telescopic engine exhaust tube, with boring attachment; H, part of the living quarters and well-equipped scientific laboratory; I, landing on ice, open when as surface craft; J, the periscope and fixed steering tower; leading to the control compartments; K, mooring gear; L, compartments to enable storage of five days supply; M, engine exhaust compartment; N, divers' compartment, airlock and exit; O, mushroom anchor; P, sonar and plankton sample hatch.

NOTE.—Captain Wilkins and his associates are busy preparing for their next effort in the early summer of 1938 and a splendid submarine in most respects to the illustration, is being built in Canada now.

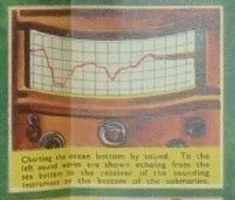


The area of operations at the top of the world, showing all the countries bordering on the Arctic, and supporting meteorological stations on many of the Arctic land areas, but no permanent stations in the central area. The dotted line shows the Wilkins-Ellsworth Expedition route covering area on which the first trans-Arctic submarine trade route will be established, and where it is hoped to discover land foundations for future meteorological and airway stations. The yellow shaded area indicates socially unexplored areas.

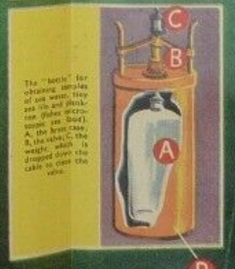
Various soundings have shown ocean depths down to three miles in some parts of the Arctic Sea, and ice thickness, A, averaging 14 ft. over greatest ocean area; B, 70 ft.; C, up to 125 ft. snags very occasionally; and D, the "pack" ice at 400 ft. "peak"; E, frequent streams and patches of fresh water on surface.



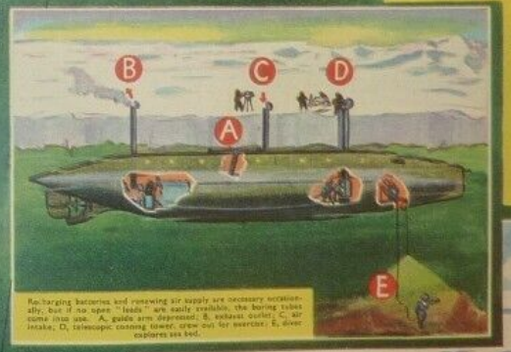
The telescopic conning tower, A, with improved boring head, B, which literally melts its way upward. The outer tube is rotated at A, its upper collar engaging the threads of the inner tube, C, which sets on the tempest tube surmounted by the electrically-heated boring head, B; entrance when stationary, D.



Charting the ocean bottom by sound. To the left sound waves are shown echoing from the sea bottom to the receiver of the sounding instrument on the bottom of the submarine.

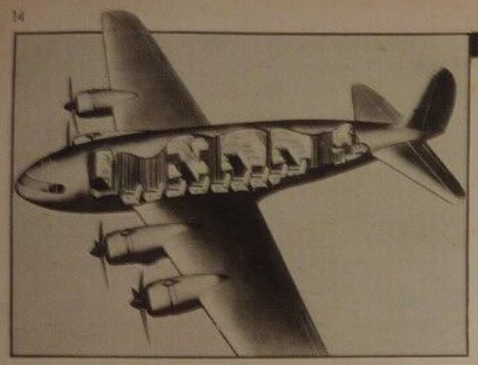


The "bottle" for obtaining samples of sea water, key area (A) and plankton (fishes microscopic sea food). A, the brass case; A, the valves; C, the weight which is dropped down the cable to open the valve.



Recharging batteries and renewing air supply are necessary occasionally, but if no open "leads" are easily available, the boring tubes come into use. A, guide arm depressed; B, exhaust outlet; C, air intake; D, telescopic conning tower, crew out for exercise; E, diver explores sea bed.

Scientific observations of every kind can be made under all sorts of weather conditions, when ship is able to "dock" in open water or "lead." Short side journeys on foot can then be made when weather is inconceivable, so vessel's cache of food and exercise are allowed (and certain laboratory work, too, possible), when submerged. A, fixed conning tower; B, telescopic tower; C, strong collapsible gangway; D, scientific experts.



TO FLY THROUGH THE STRATOSPHERE

BOEING SUB STRATOSPHERE PLANE

Long contemplated and much talked about has been the new Boeing sub-stratosphere plane. Now at last some of the rumours are at least beginning to look like fact.

Designed to fly from Europe to America in ten hours, the plane is to be one of America's biggest ships.

The above sectional drawing shows the luxurious accommodation that will be afforded the twenty-five passengers. The plane has a pressure cabin for flying at heights around 25,000 ft.

* * *

600 M.P.H. DIVE?

A report from America states that one of several planes being built for the French Government was under test, and during one of its dives the plane was known to travel at 575 m.p.h.

The report goes on to say that the plane continued its dive, but 575 m.p.h. was the maximum speed to which the air speed indicator had allowed. Thus it is believed but unconfirmable that the plane travelled at more than 600 m.p.h.

The present speed record for land planes stands at 379.66 m.p.h. Put up by Dr. Wurster in a Messerschmidt 109 fighter in November, 1937.

This, of course, is the official record as recognized by the *Federation Aeronautique Internationale*; there have been many greater speeds and nearly every fighter of any repute exceeds these speeds during test dives, but these are not recognized records.

The present record was set up over a three kilometre course, and timed by officials of the Federation. Unless a record is set up in this way complying with the rules of the Federation it cannot be recognized.

It seems strange that the present record has stood as long as it has.

A specially tuned "Spitfire" could touch that speed, even if not better it.

* * *

CHRISTMAS MAILS

Actual figures of how Imperial Airways accomplished their task of the first year of the all-up mail system are just out.

A few weeks before the job began, Imperial gave a rough estimate of some of the figures that would result. Figures reveal that their estimates were very close.

In all some 420,000 miles were flown extra to the normal services. Of these 82,000 miles were flown by the Empire Flying-boats and 200,000 by the company's landplanes. The rest of the mileage was accomplished by various planes pressed into service for the occasion.

* * *

220 M.P.H. CRUISING AIR LINER

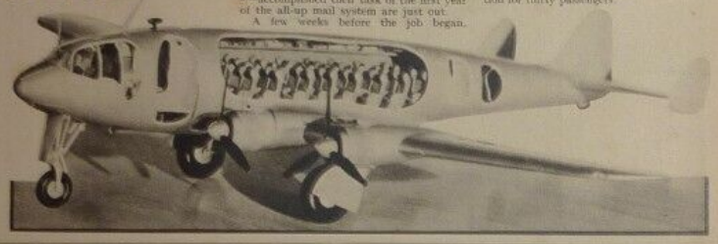
When the new Fairey Research Laboratories were opened at Hayes by Sir Kingsley Wood, details of a new commercial air liner were hinted at the same time.

The only indication to substantiate these rumours was the model in the picture below. Since that date more details have been learnt of what will be a most important plane in the future of civil aviation.

The new plane is a four-engined, low-winged monoplane. It is to be the largest and fastest in the world.

With a range that will enable it to fly non-stop to any European capital, the new liner will have a top speed of 275 m.p.h. and a cruising speed at rated altitude of 220 m.p.h.

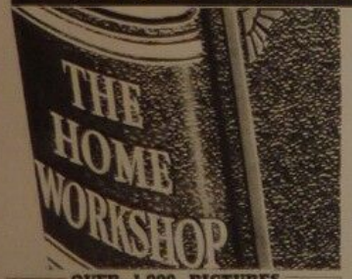
Similar to the Boeing, this plane is intended for sub-stratosphere flying and has a pressure sealed cabin with accommodation for thirty passengers.



"MODERN WONDER'S" GREAT NEW PRESENTATION

LAST CHANCE

FOR THE BOOK THAT SHOWS YOU IN PICTURES HUNDREDS AND HUNDREDS OF THINGS YOU CAN DO YOURSELF



OVER 1,000 PICTURES SHOW YOU HOW TO DO IT

Read below to get some idea of the vast scope of this work.

YOUR HOME WORKSHOP.—Describing tools, their uses, workbenches, fitting up a workshop, etc.—Working in wood.—Working in metals, etc.

USING YOUR TOOLS.—Fully described and illustrated.

SHARPENING AND FITTING.—Planes, chisels, gouges, scrapers, spokeshaves, saws, etc.—Grinding and honing tools.

FINISHING WOODWORK.—Staining and polishing.—Filling grain, pores.—Use of the woodscrew.—Laying turfs.—Concrete work.

JOINTS AND JOINTING.—Making a variety of joints.—Dovetail joints, etc.—Mitres.—Dowel joints, etc.

WOOD TURNING.—Simple lessons in turning.—Chucking.—Boring.—Screwing.—Polishing.

THINGS TO MAKE.—Hundreds useful articles.—Tables.—Stools.—Bookshelves.—Bookstands.—Trays.—Boxes.—Kitchen utensils.—Fretwork.—Inlaying.—Veneering.—Fitting hinges, locks, etc.—Household gadgets.—Kitchen, etc., etc.

HOUSE PAINTING AND DECORATING.—Distempering.—Whitewashing.—Painting.—Papering.—Graining.—Marbling.—Staining.—Varnishing.—Enamelling.—Lacquering.—Gilding.—Paint spraying.—Stencilling.—Fabric painting.—Lettering.—Sign writing.—Coloured glass.—Leaded lights.—Fixing locks, etc.—Fitting casements.—Fitting sashes.—Fitting sash cords.—Fitting sash weights.—Fitting sash fasteners.—Fitting sash stops.—Fitting sash pulleys.—Fitting sash boxes.—Fitting sash cramps.—Fitting sash lines.—Fitting sash balances.—Fitting sash frames.—Fitting sash glazing.—Fitting sash beads.—Fitting sash putty.—Fitting sash glass.—Fitting sash sashes.—Fitting sash doors.—Fitting sash windows.—Fitting sash frames.—Fitting sash glazing.—Fitting sash beads.—Fitting sash putty.—Fitting sash glass.—Fitting sash sashes.—Fitting sash doors.—Fitting sash windows.

THINGS TO MAKE AND DO FOR THE GARDEN.—Summer houses.—Rustic tables.—Arbours.—Fencing panels.—Gates.—Trellis.—Pergolas.—Paths.—Paving.—Crazy paving.—Rockeries.—Pools.—Fountains.—Sundials.—Bird baths.—Bird tables.—Bird houses.—Nesting boxes.—Bird feeders.—Bird scarers.—Bird traps.—Bird cages.—Bird aviaries.—Bird houses.—Bird nesting boxes.—Bird feeders.—Bird scarers.—Bird traps.—Bird cages.—Bird aviaries.

FOR YOUR MOTOR CYCLE OR CAR.—Lubrication.—Decarbonising.—Valve grinding.—Valve springs.—Valve guides.—Valve seats.—Valve timing.—Valve clearance.—Valve lifters.—Valve rockers.—Valve tappets.—Valve cotters.—Valve springs.—Valve guides.—Valve seats.—Valve timing.—Valve clearance.—Valve lifters.—Valve rockers.—Valve tappets.—Valve cotters.—Valve springs.—Valve guides.—Valve seats.—Valve timing.—Valve clearance.—Valve lifters.—Valve rockers.—Valve tappets.—Valve cotters.

ELECTRICITY IN THE HOME.—Electric bells.—Electric heaters.—Electric irons.—Electric cookers.—Electric fires.—Electric lamps.—Electric switches.—Electric plugs.—Electric sockets.—Electric fuses.—Electric wiring.—Electric meters.—Electric bills.—Electric accounts.—Electric tariffs.—Electric supply.—Electric current.—Electric voltage.—Electric resistance.—Electric power.—Electric energy.—Electric heat.—Electric light.—Electric sound.—Electric motion.—Electric magnetism.—Electric induction.—Electric generation.—Electric transmission.—Electric distribution.—Electric consumption.—Electric measurement.—Electric safety.—Electric accidents.—Electric first aid.—Electric regulations.—Electric standards.—Electric units.—Electric terms.—Electric symbols.—Electric diagrams.—Electric circuits.—Electric wiring.—Electric fittings.—Electric appliances.—Electric tools.—Electric workshop.—Electric home.—Electric garden.—Electric garage.—Electric car.—Electric motor cycle.—Electric bicycle.—Electric boat.—Electric aeroplane.—Electric model.—Electric toy.—Electric game.—Electric puzzle.—Electric trick.—Electric experiment.—Electric demonstration.—Electric lecture.—Electric book.—Electric magazine.—Electric newspaper.—Electric radio.—Electric television.—Electric telephone.—Electric telegraph.—Electric wireless.—Electric broadcasting.—Electric receiving.—Electric transmitting.—Electric aerial.—Electric earth.—Electric battery.—Electric accumulator.—Electric charging.—Electric discharging.—Electric testing.—Electric measuring.—Electric instruments.—Electric meters.—Electric bills.—Electric accounts.—Electric tariffs.—Electric supply.—Electric current.—Electric voltage.—Electric resistance.—Electric power.—Electric energy.—Electric heat.—Electric light.—Electric sound.—Electric motion.—Electric magnetism.—Electric induction.—Electric generation.—Electric transmission.—Electric distribution.—Electric consumption.—Electric measurement.—Electric safety.—Electric accidents.—Electric first aid.—Electric regulations.—Electric standards.—Electric units.—Electric terms.—Electric symbols.—Electric diagrams.—Electric circuits.—Electric wiring.—Electric fittings.—Electric appliances.—Electric tools.—Electric workshop.—Electric home.—Electric garden.—Electric garage.—Electric car.—Electric motor cycle.—Electric bicycle.—Electric boat.—Electric aeroplane.—Electric model.—Electric toy.—Electric game.—Electric puzzle.—Electric trick.—Electric experiment.—Electric demonstration.—Electric lecture.—Electric book.—Electric magazine.—Electric newspaper.—Electric radio.—Electric television.—Electric telephone.—Electric telegraph.—Electric wireless.—Electric broadcasting.—Electric receiving.—Electric transmitting.—Electric aerial.—Electric earth.—Electric battery.—Electric accumulator.—Electric charging.—Electric discharging.—Electric testing.—Electric measuring.—Electric instruments.

PRACTICAL HOUSEHOLD PRECAUTIONS AGAINST AIR RAIDS.—Protecting the home from incendiary bombs.—Shelters.—Making home-protected dwelling.—Keeping the home safe.—Making and protecting the home from gas.—Making and protecting the home from incendiary bombs

EUROPE'S COMMERCIAL AIR LINERS

The ten-passenger British Airways Lockheed "Electra." Maximum speed 215 m.p.h., range 830 miles.

The Avro "642." This sixteen-passenger machine has a maximum speed of 160 m.p.h., and a range of 605 miles. The engines are two Armstrong Siddeley 460 h.p. "Jaguars." First introduced in 1934 this machine has been used on air lines all over the world.

The French giant commercial landplane is the Dewoitine "338." The plane carries twenty-four passengers.

The eighteen-passenger Savoia Marchetti "S.71." This plane is an Italian-built machine, but is used by S.A.B.E.N.A., the Belgian Air Lines. The maximum speed is 200 m.p.h., and the range can be either 625 miles or 1,250 miles according to load. The plane is powered by three "Alfa Romeo" engines.

The De Havilland "Dragon Rapide" six-to eight-passenger transport biplane. Built for either commercial use or private ownership. Top speed 157 m.p.h., range 556 miles. The engines are two 200 h.p. "Gipsy-Six."

The German Dornier "D.O.18" is not a passenger-carrying machine, but a freight and mail plane with a complement of three as crew. The maximum speed is 155 m.p.h., and the range 2,765 miles.

The Short "Empire" flying boat "Canopus," one of the most famous of the class. Maximum speed, 200 m.p.h., range 760 miles which can be increased to about 2,000 miles. The complement is twenty-four passengers and a crew of five.

The ten-passenger Junkers "Ju 86" commercial monoplane can often be seen on the carmac at Croydon. The top speed is 235 m.p.h., and the range 700 miles. Powered by two Junkers "Jumo-205" engines.

Sleek-looking and very powerful is this German-built machine. The Focke Wulf "Condor" carries twenty-six passengers. This particular machine carries the Danish registration, being operated by one of the Danish air lines.

This giant four-engined air liner is a recent product of the Fokker concern in Holland. The plane is the "F.23" while the "F.37" is very similar in design.

Another heavy German Junkers machine. This "Ju. 90" carries forty passengers.

The American Northrop "Delta" used in Sweden on internal lines. Sweden has two companies operating internal services, and in addition there are six companies operating externally.

The Short "Scylla," a type of machine that has done valuable service for Imperial Airways for many years past. Now obsolete, this machine carried thirty-nine passengers.

The De Havilland "Albatross," one of the most recent machines to be added to the list of British commercial planes. The top speed is 240 m.p.h., and the range 3,000 miles. The plane has a capacity of twenty-two passengers.

The Martin "Clipper," one of America's giant flying-boats. This machine has accommodation for forty-six passengers and six crew. The maximum speed is 200 m.p.h., and the range 3,500 to 5,000 miles.

The twenty-one passenger Douglas "D.C.3" is used by the Dutch air lines, K.L.M.

The Armstrong Whitworth "Ensign." Carries forty-two passengers and five crew. Top speed is 200 m.p.h., range 760 miles.

HUGO MELVIG 1938

At one of Britain's many big locomotive building works where every year several thousands of tons of old rolling stock and locomotives are broken up for waste metal. The electric welder reduces these huge chunks of metal to pieces in a few moments.

WELDING WIZARDRY

THAT GIVES OLD METAL NEW LIFE

MANY old boys who were young boys fifty years ago will remember the delights of the first great exhibition held in Glasgow. It was a great exhibition, although the Empire Exhibition of 1938 in the same city was a hundred times bigger and contained a hundred modern wonders for every one displayed in the old show.

These were the days when the electric lamp was a new star in the scientific sky, when an illuminated fountain seemed a miracle, and switchbacks were a screaming novelty. Even the revolving gun that covered almonds with sugar was something to gaze at again and again.

Tucked away in that old exhibition was a wonder-worker that this country had never seen before. It was quite a small affair, and looked like a couple of vices. In each vice a metal rod was clamped; the ends of the rods were brought together, light began to gleam at the join, first red, then white, and then the light faded and the two rods had become one rod.

This was the first electric welder invented—or rather, discovered almost by accident—by Professor Elihu Thompson, in Philadelphia a few years before. It he had not discovered it then, it would surely have been found out very soon. For it depended on a well-known law.

Electricity, flowing along a wire, meets with resistance, much as water does in flowing along a pipe. This resistance causes heat, and the greater the resistance the greater the heat. At the touching point of two rods or wires the resistance is so high that the heat melts the metal, and a squeeze is all that is needed to make the weld complete.

Far more complete than a blacksmith's weld, which is done by heating the ends red hot and hammering them together.

Today, a thousand and one things are thus electrically welded—usually in automatic machinery. Cycle and motor car runs, barrel hoops, steel furniture for offices, wheels for watches and clocks, steel chains, pipes of all sorts, these are some of the best known examples.

The father of the other sort of welding—the "arc welding" that built the Bank of England and the *Ark Royal*—was Humphry Davy, of miner's safety lamp fame.

Over a hundred years ago Davy demonstrated to the Royal Institution that if two pencils of carbon connected to an electric battery were made to touch and then drawn apart, the current would jump across the gap in a brilliant "arc" of light.

In 1881 an engineer named De Meritens used the intense heat of the electric arc to melt lead and so weld the lead plates of electric batteries together.

The heart of an electric arc is the hottest place on earth. Its temperature is somewhere around 5,000 degrees centigrade. At a touch from the electric arc, steel and other metals flow like water.

Fiery heat, however, is only half the story of electric welding. It is not enough, if we want to mend a crack in a steel plate to join two plates of steel together, to melt the metal; we must fill up the crack or joint with steel *exactly like the steel of the plate itself*.

This is done by using a steel pencil or "electrode" instead of a carbon one. The arc not only melts the steel plate, it melts the electrode as well, and the metal flows from the electrode to fill up crack or joint.

We can, in fact, make electrodes to match any kind of steel, including stainless steel, and also cast iron, copper, brass and bronze. Electric welding, then, is more than putting on any old patch that will hold things together.

It adds new metal that melts in with the old, becoming one with it and making a strong, clean, solid job right through.

The electrodes also supply a "flux" that floats on the molten metal and protects it from the action of the air.

So it comes about that with electric welding we can do all sorts of feats in "metal surgery" which were impossible before. In the old days, if a casting broke or cracked, there was nothing for it but the scrap heap.

Now we can knit it together far more easily than a surgeon can mend a broken bone. If we like, we can make it stronger than ever by welding new metal on to the weak parts.

Railway points and crossings, when worn out of shape, used to be scrapped. Now they are made good with welded metal, and what is more the work can be done on the track, without taking them out. A few years ago, the L.M.S., using twenty-two electric welding sets, gave a second life to 3,500 crossings.

The L.M.S. has also experimented with welded rail joints to give smoother and quieter running. Five hundred feet lengths have been welded into a continuous rail.

Here the only snag is that expansion and contraction under heat and cold may —it is not yet known for certain—cause the long length to buckle.

There is, indeed, no limit to the triumphs of plastic metal surgery. Anything, big or small, offers a chance for the welder's skill. Old bridges can be strengthened by welding on new webs or ties.

Worn crankshafts of engines can be built up to the correct shape again. Ships' propellers pitted by sea erosion or broken can be filled in and made whole.

On the small side, worn-out chisels and other tools can have a new tip of cutting steel welded on to the shank. Old gear wheels which have begun to rattle are brought back to their original shape.

But it is not only in the casualty wards of engineering that the welding surgeon gets busy. He makes as well as mends.

The welder has brought a new word into the workshop—the word "fabricated." Frames of the big machines, like electric generators and motors, used to be cast in the foundry. Now they are built up, or "fabricated," out of sections of steel welded together. Fabricated units are cheaper, quickly made, and both lighter and stronger than castings.

It is to the riveter, however, more than to the foundryman, that electric welding holds out its biggest challenge.

Engineers who had, as it were, riveted their faith to rivets, found it hard to admit that welded plates and girders could be as strong as those held together by well-hammered rivets. They scoffed when the champions of welding claimed that welding was even stronger.

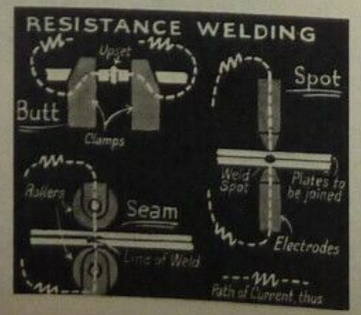
The first great success scored by the welders was the gallant ship *Fullagar*. Built at the famous Cammell Laird yard at Birkenhead in 1920, the *Fullagar* (400 tons) was the first sea-going vessel with no rivets. Everything—hull, decks, bulkheads, and so on, was electrically welded.

On a voyage from Liverpool to Belfast she went hard aground. Floating off on the next high tide she completed her trip. Although badly damaged, she was found to be water-tight, so back she went to Liverpool for repairs in dry dock. When she was examined the opinion was expressed that if she had been a riveted ship she would have been a total loss.

Several times she repeated this process of going aground and getting off without letting in a drop of water. In a collision her hull was dented but showed no leak. Licensed at first as a coaster, she proved so seaworthy that she was allowed to go on ocean service.

Other all-welded ships followed; their names appear in the "A.1 at Lloyds" list.

The day will surely come when big ships as well as little will be welded throughout. Electric welding was used for certain sections of the *Queen Mary*, and these have stood up well to the stress and strain of service.



(Extreme left) **Here is shown the electric welding arc in which a coated electrode is employed. It is essential to keep oxygen away from the molten metal and so a coating that will give off an inert gas is extruded round the rod.** *(Left)* **Three methods of resistance welding. Butt welding is used to join lengths of rod, tube or other metal sections. Spot welding takes the place of riveting for joining plates and seam welding produces a continuous seam.**

SCIENCE of the SIEGE GUNNER

MODERN warfare with its lavish use of concrete fortifications calls for enormous quantities of high explosive for the destruction of the concrete works of the enemy.

This can best be thrown at them by gunfire, more especially from guns of the howitzer type, which are designed for high angle fire.

In destroying heavy emplacements this is a great advantage, because added destructive power is provided by the steep angle at which the shell falls.

The howitzer is a short type of gun, of no great power, that fires its projectile upwards, as distinct from the high-velocity gun that throws its shell as nearly straight at the target as possible.

The path of every projectile is a beautiful curve, known as a parabola, and no projectile follows a straight line at any part of its flight.

The spin given to it by the rifling in the gun causes it to drift out of a direct line, to the right of the target, so the gunner has actually to lay his gun to the left of the work he is out to destroy, if he is going to hit it. And even then he cannot be sure (see the centre drawings) that he will hit it more than five times out of one hundred.

Howitzers are laid on their targets first by taking compass bearings, but there are many things to take into account. The shell travels high into the air, may be several thousand feet, and the wind it meets must be allowed for, also the density of the air, and its temperature, these have an important bearing on the accuracy of fire.

Enormous pressures are set up in the chamber of the gun, and in an eight-inch howitzer, firing a shell weighing 200 lbs., this may amount to no less than 30,000 lbs. to the square inch!

The drawing at the top shows details of the flight of the shell. The angle of elevation is the tilt that has to be put on the gun to ensure the full distance being carried by the shell, the range is the exact distance between gun and target, but the distance travelled by the shell is much greater than this.

THE shell in flight is given a spin by the rifling inside the gun, to keep it flight true. The spin given to an 8-in. shell may be only one turn in 20 ft. travel, but it is spinning at 5,800 revolutions a minute.

This rotation releases the safety catches inside the fuse, by centrifugal action and renders it fully sensitive, so that the detonator is set off immediately the shell strikes its objective.

Note in the picture how the rifling has cut the copper driving band. This driving band is put on, not only to give the shell the necessary spin, but also to seal the bore against possibility of escaping gas pressure. The gun designer thinks of the length of his gun in "calibres," which means that the length of the bore is reckoned in terms of the shell diameter. In this case the gun would be fifteen calibres in length and the rifling would make only half a turn in the gun.

One hundred rounds are fired from a fixed gun, and the diagram above and below explains how the shells fall in two oval areas, fifty in a wide area, and fifty smothering the target.

The shell of an 8-in. howitzer leaves the muzzle at nearly 2,000 ft. per second and will strike a target five miles away at 1,000 ft. per second. Its weight is about 200 lb.

To throw the shell out of this howitzer a pressure of 14 tons to the square inch is generated by the charge of cordite.

"Big Bertha," the famous gun used by the Germans to bombard Paris in 1918, had a range of more than 75 miles. The shell weighed 300 lb. and was 8½ ins. diameter. The muzzle velocity was 5,250 ft. per second, the pressure in the gun (which was 122 ft. long) amounted to 67,000 lb. per square inch. At the top of the trajectory the shell was 27 miles above the ground from which it started!

Big Bertha's shell was of a special design, a hollow streamlined cowl being added to give extra range. The bursting charge was composed of two liquids, but few details have ever leaked out concerning this remarkable weapon.

HOW WARSHIPS CARRY THEIR AIRCRAFT

H.M.S. *Warspite*, as reconditioned, showing 1, catapult; 2, hangar; 3, cranes for handling boats and aircraft; 4, catapulted plane.

The *Warspite* has a main armament of 15-in., 6-in. and A.A. guns. Originally it had two funnels and tripod mast.

The French battleship Dunkerque carries her air equipment aft on the quarterdeck. She is armed with 13-in., 5.1-in. and A.A. guns.

Detailed view of the *Dunkerque*: 1, catapult; 2, hangar; 3, hangar entrance; 4, crane; 5, 5.1-in. guns in turrets.

ALTHOUGH the carrying of aircraft by warships has been a familiar sight for a long time, it is only within the last two or three years that vessels have been specially designed or converted to facilitate this idea.

All new battleships and cruisers now carry hangars as well as catapults and cranes, whilst many existing vessels have been reconstructed to accommodate aircraft. Some examples of both are shown on these pages.

The example of the latter case is illustrated by H.M.S. *Repulse* and H.M.S. *Warspite*. The cruisers *Southampton*, *Brooklyn* and *La Galissonniere* are specially designed ships.

Two types of British shipboard aircraft are shown: (*left*) the Supermarine "Walrus" Amphibian Flying Boat! and (*right*) the Hawker "Osprey," two-seater reconnaissance seaplane.

H.M.S. *Vindictive* was first British warship equipped with catapult and hangar. 1, catapult; 2, hangar; 3, crane.

The two silhouettes on (left) afford an interesting comparison. H.M.S. *Vindictive* has had a varied career and illustrates the undecided attitude towards the shipboard aircraft problem. Originally intended as a cruiser, she was completed as an aircraft carrier with a large landing deck aft and flying-off deck forward. Later she was reconverted to a cruiser similar to the silhouette, retaining her hangar. In 1937 she was refitted once more, this time completely changing her appearance, to a single-funnelled ship. H.M.S. *Southampton* is, of course, one of our latest cruisers and is the last word in the shipboard aircraft problem.

H.M.S. *Southampton* illustrating position and arrangement of aircraft equipment in comparison with the above: 1, athwartships catapult; 2, hangar; 3, cranes (see circle).

H.M.S. *Repulse* (*left centre*) has undergone radical changes. A large hangar to accommodate several aircraft has been built up around the second funnel. This is surmounted with two cranes. Boat stowage is also shown. The cranes handle both aircraft and boats. The new type of catapult installed is a feature of many British warships today. 1, catapult; 2, hangar; 3, hangar doors and entrance; 4, cranes; 5, "Osprey" aircraft ready for take off; 6, A.A. guns; 7, twin A.A. guns. The *Repulse* is armed with 15-in., 4-in. and A.A. guns.

H.M.S. *Cumberland*, as originally completed. No hangar provided. 1 aircraft was carried.

Key to numbers for both silhouettes: 1, catapult; 2, hangar; 3, crane; 4, quarter-deck cut down to compensate weight of hangar.

H.M.S. *Cumberland* as reconstructed. Note the athwartships catapult, large hangar for several aircraft and quarterdeck cut away.

H.M.S. *Repulse*, original appearance: 1, catapult; 2, boom to lift aircraft; 3, flying platform.

H.M.S. *Repulse* as reconstructed showing: 1, crane; 2, hangar; 3, crane.

The United States Navy have been the foremost pioneers in aircraft carrying. Seldom less than two catapults and four planes are carried by every large ship. The "Brooklyn" Class illustrated, have a hangar specially designed and built into the hull aft. They are the first warships to be so constructed.

Key to numbers: 1, starboard catapult; 2, port catapult; 3, electric lift; 4, crane; 5, hangar. The presence of the hangar accounts for wide square stern and also gives after guns a higher command of fire.

(Above) Detailed view of the *Southampton* showing her hangars built round the fore funnel. A Supermarine "Walrus" is on the catapult which is of the fixed athwartships type. This vessel is armed with 6-in., 4-in. and A.A. guns.

Shipboard seaplane as used by the United States Navy. The Curtiss S.O.C.-1, is a scout observation plane seating two.

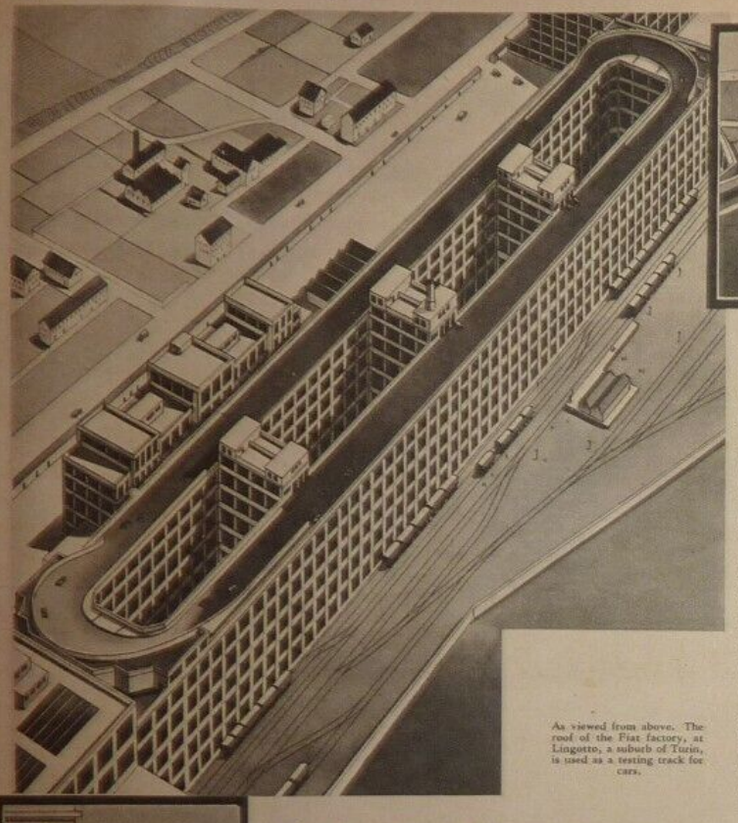
Here is a flying-off platform as used by British battleships in the Great War. Sopwith "Pup" aircraft were largely used although the Royal Naval Air Service, largely responsible for the launch of the service, embraced many other types of machines among them some successful early seaplanes.

The above sketch shows the early method adopted by light cruisers of the "C" and "D" classes. A hangar 1, to accommodate one Sopwith aeroplane was situated forward of the bridge 2; a flying-off platform eight feet in length, 3 was provided. With the ship steaming at full speed into the wind the aircraft would take off.

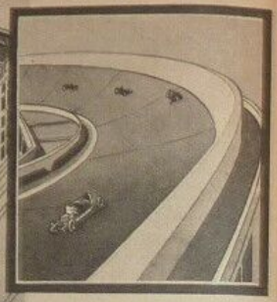
Shipboard seaplane as used by French Navy. The Loise et Olivier "H-43" is a three-seater reconnaissance seaplane.

All large French warships are fitted with catapults but not many with hangar space. The "La Gallissoniere" Class however, is fitted with a large hangar aft to accommodate several planes. The vessel is armed with 6-in., 3.5 A.A. guns and has a speed of over 30 knots.

Key to numbers: 1, catapult mounted on turret; 2, hangar; 3, hangar entrance; 4, crane; 5, rails for moving crane; 6, opening for Hein mat gear. These ships are the only vessels with a movable crane and permanent Hein mat fittings. The Hein mat is a form of landing pontoon upon which a seaplane can taxi whilst the vessel is in motion.



As viewed from above. The roof of the Fiat factory, at Lingotto, a suburb of Turin, is used as a testing track for cars.



The two end sections of the roof track are banked like a racing track, so that tests can be carried out at reasonable speeds.

Cars ascend to the roof by means of two spiral ramps built one at each end of the building.

CAR RACING on a ROOF!

On the roof of their factory Fiat Motor Company have built the perfect test road

SOME of the keenest brains in the world have been devoted, during recent years, to the increasingly pressing question of roads safe for motorists. Road-building for motor traffic—to the complete exclusion of walkers, cyclists, horse vehicles and so on—is seen at its best on the Continent.

On these autostradas, for permission to motor on which a special fee is charged, one may be held up for dawdling—not for speeding. The only speed limit imposed is below about fifty miles per hour.

Such Continental roads, for swift motor traffic only, have no danger spots in the form of side turnings or concealed bends; the special road is either carried over or under essential crossings. They are not for racing purposes, simply for the convenience of motorists in a hurry.

They would, of course, do splendidly for competitive "third-tests" such as staged at Brooklands, and also for car testing purposes by manufacturers, but then that would rob the autostradas completely of their special purpose.

The car testing problem led to the construction of a road which is unique in the world. It is on a factory roof, and apart from the necessary difference in length, it has all the advantages of a first-class public racing track. How this novel roof-track came into being is a story wrapped up in the progressive history of the great Italian firm of Fiat.

Those letters, taken as initials, have been interpreted in many ways. They stand for *Fabbrica Italiana Automobili Torino*, the title of Italy's first motor car factory.

Started with fifty workmen in a small workshop, the concern has thirty thousand employees now on its pay-roll and the original motor car business has extended to the manufacture of practically every form of motor transport, on the sea and in the air as well as on land.

Forty years ago that small beginning was in a suburb of Turin, named Lingotto. Now it is no longer a suburb, but the industrial heart of Turin city. The country has receded farther and farther—and with that recession of open land went any possibility of the building of a car testing track on solid ground.

The owners of the concern began to take serious thought. Other concerns, also cramped for elbow room, have built upwards, scraping the skies with dizzily towering erections. Elsewhere, building has been extended downwards, far beneath the surface. Even public car parks have had to dodge from the open and tuck themselves away in subterranean regions for lack of space under the skies.

Sunken car parks—why not an *elevated* testing track? And so it came about that the Fiat people constructed a race-road on their roof. A wildly daring project, with no previous example from which the engineers could learn a lesson.

There is a limit to the liberties you can take with a building. What was wanted, in this case, was a perfect-surfaced roof road on which cars straight from the finishing shop could roar full out and do as many circuits of the track as the test driver thought necessary.

Strains and stresses would be set up such as would bring any normally constructed building clattering to the ground in ruins. But all those difficulties were dealt with, first in the drawing-office and then through the medium of steel and concrete. The elevated road became an actuality, reached with the greatest of ease by cars and even heavy lorries via spiral roads constructed at each end of the building.

Winding up through the various floors of the factory go vehicles to be tested, then out on to the open "road" of which, ordinarily, only an aeroplane might make use.

As the drivers pass up the spiral roadway to the roof track, they are climbing the production ladder of the Fiat car. Each of the floors upwards indicates a new stage in the process, until on the top floor the finished car rolls out of the shop on to the roof ready to undergo its tests.

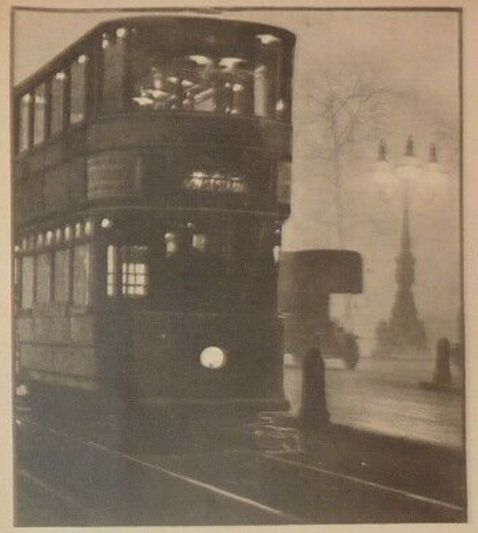
The track for surfacing would rival many a famed racing circuit. The banked corners are a perfect specimen of road building.

So great is the length of the straights, that looking along their broad white surfaces, they seem to vanish in a point in the distance.

The Fiat factories extend for about one and a quarter miles in length, occupying an area of 428,056 square yards. The main building is 1,664 feet long and 265 feet wide, consisting of two longitudinal and parallel structures eighty-eight feet six inches high.

It is the top of those two structures and of the two end cross buildings that carries the unique testing track. The actual width of the latter is seventy-eight feet nine inches, and the length of the two straights is 1,423 feet. Joined by the end tracks it forms a road without end, cars reaching it from the workshops below through one opening and descending from it by another.

It's a truism that one can become used to anything. The testers themselves have ceased to wonder at their job of driving upstairs, then roaring flat-out round and round the roof, then down to earth again—a driving experience to which not many purchasers of the so tested cars would care to submit.



The gloomy murkiness of a London fog on the Embankment.

Every quarter of an hour a certain volume of air is sucked through this funnel by water suction at the L.C.C. Record Station at Battersea Park.

Air, as it is sucked through the filter paper, automatically registers the amount of dirt at the time.

FOG

THE MURKY MENACE OF CITY LIFE AND HOW IT IS FOUGHT

"EVERYBODY grumbles about the weather, but nobody does anything about it."

So said Mark Twain. Maybe he meant the remark to include fog; maybe not.

Fog is, anyway, part of the weather—about the worst part, you may think—but somebody is certainly doing something about it . . . various inventors and the National Smoke Abatement Society, for instance.

But there is a long way to go yet before Weather Enemy Number One is beaten. A lamentably long way. Town dwellers haven't even taken out of it the sting that they themselves put in.

Fog, is at the best, a dangerous nuisance. In the towns it is a deadly danger. It is a costly and calamitous curse.

Fogs are plum—or coloured. Natural white fog is bad, but the coloured varieties—pea-soup, brown or black—are bad enough for almost any description of which you can think.

To begin with, what is fog? To specify what it is not, it isn't vapour. It is water in fine particles, each one of which surrounds a particle of dust like a cherry does a cherry-stone. Fogs form when there is water-vapour in the air and the temperature drops to a point where it condenses, just as the steam (water-vapour) in a bathroom will condense on a cold wall or window pane.

The water droplets on a wall or window are visible to the naked eye, but those floating in the air as a fog are so small that two thousand of them side by side would just about span the diameter of a half-penny.

In the country, or at sea, the dust is cleaner than that in cities; hence the white fogs in one place and the pea-soupers in another. Just how filthy is the dust particle core of town fogs that produce that throat-strangling effect with which city dwellers are so familiar, we shall see presently.

Of all the big cities in this country, London is the sootiest and the foggiest. It has held a perversely proud reputation in that line both before and since the time of Charles Dickens and his "London Particulars." On every square mile of streets, houses, factories and gardens of the great metropolis rains down each year an average of two hundred and eighty tons of soot.

If it could be heaped up around the Nelson Column it would reach half-way to Nelson.

Unfortunately, it never can. It remains floating in the air, blocking out the sun's light, as aerial pollution—atmospheric sewage. That air-borne soot is the sole cause of black city fogs. And it is home-made.

It is made in the chimneys of a myriad homes; your home and mine. Factories, big industrial concerns, have smoke-consuming apparatus, and they produce less than half as much as that "cheery coal fire" we love to sit by.

So fogs, as he knows them, are the city dweller's own fault. The black city pollution is enough of a danger and a nuisance even when the winds can blow it away, but when the choking "smog" descends, deaths from respiratory diseases leap up to six times normal.

The Department of Scientific and Industrial Research maintains a chain of atmospheric pollution observation stations, dotted all over the London area, where the smoke nuisance is accurately recorded by apparatus designed by Dr. J. S. Owens, the great authority on the subject.

The method is that, automatically every fifteen minutes a regulated volume of air is drawn through a funnel by means of water suction, the air being led through a tube to a white paper filter.

A recording device then registers the amount of dirt caught by the filter and it is thus possible to obtain an accurate picture of the state of air pollution practically continuously throughout the year. These recording stations are situated at many points in the County of London, the districts of which naturally vary in the amount of soot they produce according to the local conditions.

There are very few factories in the Westminster area, but, unexpectedly that is the worst of the lot. The station at the Westminster City Hall and the one in Victoria Street, near the Houses of Parliament, between them showed the highest atmospheric soot-concentration of all—nearly five times as much as, for instance, an outlying district like New Cross.

The Office of Works recently had to spend £140,000 on cleaning and renewal of the stonework of public buildings in its charge. For months the Houses of Parliament were in splints while an army of workmen crawled about the scaffolding dissolving and chipping away at the encrustation, which had eaten deep into the very stone itself, deposited there by soot from thousands of "cheery coal fires."

Next time you're in London, take a close-up look at Cleopatra's Needle on the Embankment. That stone was quarried and carved in Egypt 3,430 years before it was brought to London, where it arrived as good as new; the clean air of Egypt had not affected it. It has been amongst the logs for merely 65 years, and carefully protected from them by the best known methods till that time—and now look at it! It is distinctly the worse for wear.

The soft coal soot-pall over London city is composed of crude tar, sulphuric acid—which eats away the stone—finely powdered ash, grit and carbon—a combination of poisons which is as noxious as it is deadly dangerous. These things, if extracted from the coal instead of being let loose in the air, could have been turned into some of the dimest of coal's by-products: aspirin and other drugs, plastics, fertilizers, dyes and so forth.

What is the remedy? The typical passenger or black town fog could be prevented—it has been greatly minimized in the last sixteen years—if only concerted action could be taken. The increasing use of gas has helped, and the wider use of smokeless coal would again help.

As to actually dissipating fog once they come—including the natural winds which can't be prevented—there have been several ideas put forward.

In Belgium the Meuse Valley has come to be known as Death Valley because of its soot-fogs. A few months ago Belgian scientists sought the help of our own Professor J. S. Haldane, who told them that, although there had been sixty-three deaths in three days through fog-poisoning in Death Valley, there had never been even one such case in the thicker and heavier fogs of London.

The reason, he suggested, was that the warmth of town created an upward thought which carried the poisons to the upper air. Thus it was that, when the next fog descended, the Belgian scientists lit huge bonfires in the smoke-producing areas.

They turned all right. Next morning Death Valley itself was clear of fog, but the regions around were shrouded in thick, white mist. The fires around the factories had carried the soot away, and airmen who went up to discover, reported that the fog was being drained upwards to one foot. Even famous then chimneys had been shown the ground were unable to descend.

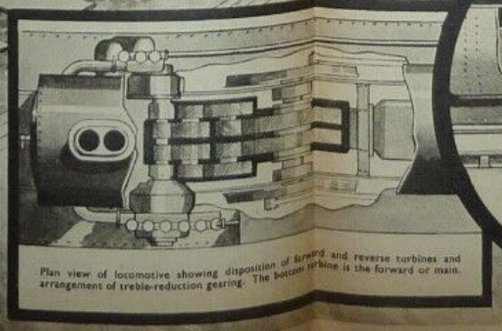
In America an even more spectacular idea was tried out. Mr. H. G. Houghton, of the Massachusetts Institute of Technology, squirted through fine nozzles a secret compound of hot oven irons a thick white sea-fog, which caused the mist to divide and roll back like the Red Sea when Moses stayed over. The method was a chemical one, but, though the invention would not reveal the nature of it, it was seen that the effect was to cause the fog water particles to combine together and fall of their own weight.

A park official examining a glass cylinder coated with lead peroxide. As the impurities in the air are mainly sulphur oxide, lead peroxide is used because of the chemical change it undergoes.

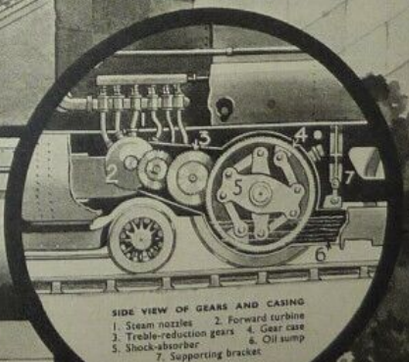
BRITISH TURBINE-DRIVEN LOCOMOTIVE

KEY TO PARTS

1. Ventilator for lubricating oil
2. Reverse turbine
3. Exhaust steam duct
4. Forward turbine
5. Gear case
6. Driving wheel
7. Steam nozzles
8. Steam chest
9. Nozzle control rod
10. Superheated steam pipe to turbine
11, 11a. Double blast pipes
12. Superheater pipes
13. Superheater
14. Regulating valve
15. Double-bore chimney
16. Superheater and fire tubes
17. Water level in boiler
18. Water supply pipe
19. Steam pipe to superheater
20. Water supply clack valves
21. Steam inlet pipe
22. Driver's regulating rod
23. Reverse turbine control rods
24. Fire box
25. Four safety valves
26. Glass windscreen
27. Turbine nozzle controls



Plan view of locomotive showing disposition of forward and reverse turbines and arrangement of treble-reduction gearing. The bottom turbine is the forward or main.



SIDE VIEW OF GEARS AND CASING

1. Steam nozzles
2. Forward turbine
3. Treble-reduction gears
4. Gear case
5. Shock-absorber
6. Oil sump
7. Supporting bracket

AN interesting development in British locomotive design is the introduction of a turbine-driven express locomotive by the L.M.S.

Two separate turbines are employed for forward and backward running respectively, and are fitted on either side of the engine, the steam supply being controlled by an ordinary regulator in conjunction with special steam valves or nozzles on the turbines—six for the forward turbine and three for the reverse. The forward or main turbine is of 2,500 h.p., and of the non-condensing type, using steam at 250 lb. per sq. in.

Owing to the low pressure of the exhaust a double blast pipe and double-bore chimney are fitted. The turbines drive the front pair of driving wheels by means of three sets of gears called treble-reduction gearing. The gears are completely encased and run in an oil bath. In order to take the shock arising from the transmission, shock-absorbers are fitted inside the final gear, thus ensuring a smooth drive when starting.

The reverse turbine is only used for shunting, and backing. A large ventilator is fitted in front of the smoke box for cooling the oil as it is pumped back to the sump in which the gears run. An unusual feature is the absence of the loud puffing which occurs with an ordinary engine. Creditable performances have been put up by this locomotive, and a saving of 15 per cent in coal has been aimed at. Should it prove a failure this locomotive can readily be converted to the ordinary reciprocating type.

POLAND'S CONTRIBUTION TO THE NAVY

THREE Polish destroyers escaped from the Baltic prior to the outbreak of war and have now joined the British anti-submarine patrols in the English Channel. They are the *Grom* and *Blyskawica* (2,144 tons), built by J. Samuel White & Co. Ltd., and the *Burza* (1,540 tons), a vessel of French design.

DETAILS OF THE BRIDGE (CIRCLE) OF THE GROM

1, Captain on bridge; 2, voice pipe; 3, compass; 4, helmsman; 5, wheelhouse; 6, chartroom; 7, binnacle; 8, machine-gun; 9, signal lamp; 10, searchlight; 11, main range finder; 12, semaphore

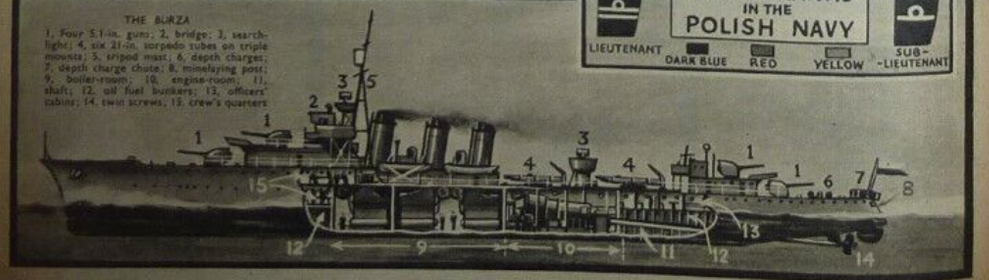
THE GROM AND BLYSKAWICA

Key to numbers: 1, Anchor; 2, capstans and anchor gear; 3, breakwater; 4, single 4.7-in. gun; 5, blast screen; 6, twin 4.7-in. guns; 7, bridge; 8, signal shutter lamp; 9, crow's nest and searchlight; 10, tripod mast; 11, machine-gun; 12, Carley float; 13, sea-boat; 14 and 16, twin 4.7-in. m. A.A. guns; 15, triple 21-in. torpedo tubes; 17, depth charges; 18, depth charge throwers; 19, triple 21-in. torpedo tubes; 20, machine-guns; 21, after-searchlight and control; 22 and 23, after-twin 4.7-in. guns; 24, depth charge chutes

KENNETH R. SIBLEY

THE BURZA

1, Four 5.1-in. guns; 2, bridge; 3, searchlight; 4, six 21-in. torpedo tubes on triple mounts; 5, tripod mast; 6, depth charges; 7, depth charge chute; 8, mine-laying post; 9, boiler-room; 10, engine-room; 11, shaft; 12, oil fuel bunkers; 13, officers' cabins; 14, twin screws; 15, crew's quarters



Modern Wonder

COAL GAS TO DRIVE CARS AND BUSES

OFFICIAL government alternative to motor spirit has recently been tested with interesting results. A portable gasworks is fitted on cars to produce carbon monoxide gas to take the place of petrol vapour. Anthracite or other solid fuel is burnt in the gas producer.

A bit slow to start up—it may take as long as five minutes with the aid of a petrol soaked rag—but once the car gets going, top speed of fifty miles an hour can be obtained on a 10 h.p. model.

Although a certain amount of loss of power is noticed, especially in hill climbs, a very attractive angle on this new fuel is that a small family car can cover a hundred miles for about 3s. 9d., the price of a hundredweight of anthracite. The same journey would cost about 6s. 3d. in petrol.

Driving controls are little different. Just an air lever in addition to the ordinary ones. At first the extra lever may seem a little tricky, but once you get accustomed to it there isn't much difficulty.

The gas plant goes on the back, or if you prefer it, is towed behind. Complete with enough fuel to travel 140 miles, it weighs about 2½ cwt. Fitted to private cars its cost is from £70 to £100.

Already in London we have seen the results of these experiments, for one or two buses are using Producer Gas trailers as an alternative to motor spirit.

✦

SPIDERS HELP TO WIN WAR

Canaries detect poison gas, carrier pigeons take messages, and now even the humble spider has a wartime job.

Every precision optical instrument used by the Forces makes use of cross-hairs. Telescopic gun and bomb sights, rangefinders and telescopes use the fine filaments which are really not hairs at all. They are usually spiderweb threads.

Stronger than steel wires of the same size, they are very fine and sufficiently elastic to hold themselves tight and straight. Only platinum wire can be used in their place, and that is usually too coarse.

Collecting the spiderweb is a delicate business. First the spider has to be persuaded to jump so that it spins thread as it drops. People who collect the spiderweb filaments often use a wooden fork and as the spider jumps, reel up the silk. Even more difficult is the job of the skilled craftsmen who mount the threads across the eye-pieces of instruments.

As spiders usually spin their thread double, skill and good eyesight are necessary to split it. Threads are so strong that they seldom break when an instrument is in service, but even if they do, an ordinary common or garden spider will soon provide a resourceful person with an immediate replacement.

Of all the types of spiders the most useful for this purpose is the ordinary garden variety that build wheel-shaped webs.

✦

FLOATING CONCRETE

Built entirely of reinforced concrete, ocean-going steamers may soon be constructed in British shipyards.

During the Great War some Continental countries went in for this kind of construction and America has found them fairly successful since. Great advantages of this kind of ship are saving in skilled labour and steel. Vessels need little expenditure in upkeep costs—painting and cleaning are unnecessary—and elaborate shipyard equipment is dispensed with. Ordinary gear used by a building contractor is all that is needed.

As it is easier to construct this type of ship keel uppermost, launching is often upside-down. Watertight compartments keep the vessel afloat until the flooding of the compartments on one side causes the ship to turn turtle and float on an even keel.

Perfectly seaworthy and much cheaper to construct than steel vessels, at least two of the few built in British shipyards are still in service and good conditions.

With the price of steel vessels mounting every day, it is probable that this method of construction will be given a proper trial. The fact that concrete can be obtained easily is one very big reason to give the scheme a real chance. Add to that the fact that little skilled labour is required and time for construction is greatly reduced, there seems to be a big future for concrete ships.

THOSE DEATH RAYS

Every week since September the Ministry of Supply has received some three hundred brainwaves from inventors who think that they have discovered the idea to save the country. Some are weird and fantastic; others may be developed usefully.

Since the Great War hundreds of inventors have been trying to produce a "death ray"—some method which through its sudden mysteriousness will terrorize as well as destroy.

A claim that such a ray has been produced comes from America. Invisible rays have been sent out from a machine sufficiently powerful to kill pigeons four miles away. Seen in action, it is stated that the rays also succeeded in stalling car and aeroplane engines at long range.

Will this apparatus be used in the war? The answer so far as this inventor is concerned is a decisive no. Realizing the tremendous power which such an invention would release, it's originator has destroyed his machine. But whether some other researcher will stumble upon the particular wave used is another question.

Death rays for insects are an accomplished fact, however. Nearly all the high frequency rays—ultra-violet, X-rays and infra-red—can be used for killing them. Even very short radio waves have the effect of burning the insides of some insects, and infra-red rays directed at a cockroach will frizzle it up in a second.

✦

ROTORS THAT ROLL UP

American inventors and scientists are also doing their bit in the field of amazing discoveries for wartime use.

Among the latest American patents mentioned in the Official Gazette, is one that provides for the rolling up of the overhead rotors on rotating wing aircraft (autogyros, helicopters, gyroplanes, etc.).

The inventor has produced a rotor that is hollow and is hinged at several places along its length. When the pilot wishes to open the rotors air is automatically blown into them and, rather similar to a carnival novelty we know of, the rotor uncurls from round its drum. Each blade of the rotor is then a straight arm, but as soon as it is desired to replace the rotors round the drum the air blast entering the blade is cut off and the blade recoils.

It is difficult to see exactly what application this invention will have. There is already a most thorough system whereby the long rotor blades of rotating wing aircraft can be folded back over the tail to facilitate easy stowage. The new method may, however, find some application here.

✦

ONCE STARTED MIGHT NEVER STOP

A ticklish experiment being carried out by scientists may result in the discovery of an explosive a million times more powerful than dynamite. What a boon this would make!

The Secretary for Mines, inspecting one of the producer gas vehicles which are to be seen on the roads today. Cars can have either trailers or small producers fixed to their bodies, either in front or at the rear.

No wonder they are afraid to start in motion a chemical reaction which once set going may be impossible to stop. The new explosive is based on the knowledge that with the splitting of the atom tremendous energy is released. Using uranium, the heaviest metal known to science, atomic bombardment has succeeded in chipping off tiny fragments.

Latest research has shown that high-speed neutrons can be released. If they are allowed to escape they are not dangerous, but if released into a lump of the metal a kind of "perpetual motion" reaction is set up. A lump of uranium may therefore become a bomb which knocks itself in pieces.

✦

EYESIGHT RESTORED BY "SPOT-WELDING"

Modern eye surgeons now treat threatened blindness with an operation very similar to spot-welding.

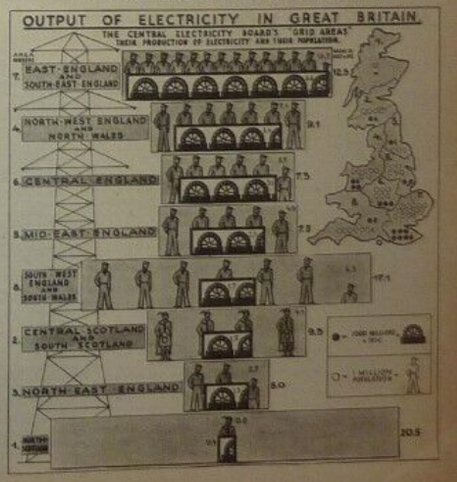
The light-sensitive part of the eye, the retina, sends the images that the eye sees to the brain. Tissue is necessary to nourish the retina and sometimes this gets diseased so that a curtain-feeling is experienced. Unless treated, the retina peels away from the tissue and blindness results.

Method had to be found to re-attach the two parts of the eye. So tiny needles carrying electric current are applied to the tissue without puncturing it. The effect of the electric shock is to cause inflammation producing an adhesive discharge which welds the tissue and retina together.

Although this method is new, surprisingly good results have been reported. One person in three, previously faced with total blindness can be helped.

As a recent discovery the full extent of cures isn't yet available, and it is hoped by the experts that in future operations of at least twice the present success will be obtained.

✦ PICTORIAL STATISTICS



NAVAL CROWN

THE LATEST ADDITION TO BRITAIN'S INVINCIBLE MIGHT

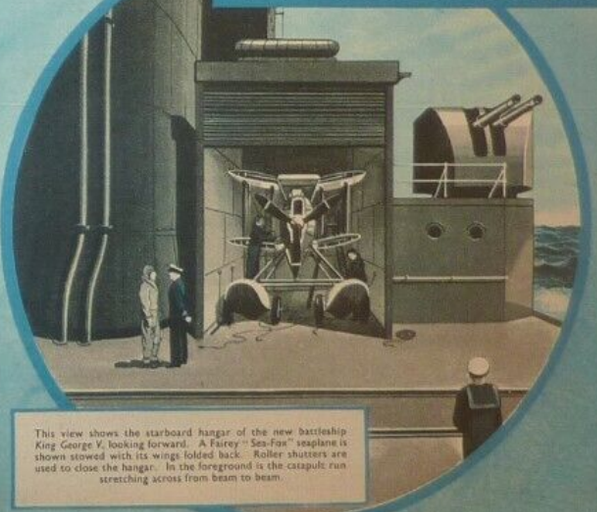
THE NEW BATTLESHIP KING GEORGE V AS SHE WILL APPEAR WHEN COMPLETED

LAUNCHED by H.M. The King in February, the new battleship, King George V, is the first of an entirely new type of 35,000 tons capital ship; five more are under construction. Our artist's impression of the completed vessel shows details that are unique among the world's warships. She will be the Navy's safest ship, as she has new forms of protection against torpedo, gun and air attack, and will be the first British battleship to mount four big guns in one turret. Her main armament consists of ten 14-inch guns which are carried in two quadruple and one twin turret. The four-gun turrets alone weigh 2,000 tons each.

Her secondary armament battery consists of sixteen of the new 5.25 guns in twin turrets. There are many eight-barrel multiple pom-poms, and other anti-aircraft guns for her aerial defence. There will be two hangars for aircraft—one on each side of the fore funnel, with a fixed cross-deck catapult between the funnels. She is the first British battleship to be launched in fifteen years, and will have cost £8,000,000, when completed, being the very last word in naval construction.

A close-up of the new 5.25-inch high-angle guns in twin turrets. Sixteen of these guns go to make up the secondary armament of the new battleship and although their rate of fire is secret they can be elevated to an angle of sixty degrees. The ammunition trunk extends down to the shell rooms below decks

The new Fairey "Sea-Fox" is specially designed for reconnaissance duties at sea, and is carried on battleships and cruisers. *Key to numbers.*—1, 395 h.p. Napier "Rapier VI" engine; 2, Pilot; 3, Observer gunner; 4, Catapult legs; 5, Floats; 6, Water rudders; 7, Catapult trolley legs.



This view shows the starboard hangar of the new battleship *King George V*, looking forward. A Fairey "Sea-Fox" seaplane is shown stowed with its wings folded back. Roller shutters are used to close the hangar. In the foreground is the catapult run stretching across from beam to beam.

ASHWELL L. WOOD

KEY TO PARTS SHOWN ABOVE

1. Raked bows
2. Jack staff
3. Port anchor
4. Hawsed holes for two starboard anchors
5. Capstans
6. Breakwater
7. Steering wire
8. "A" turret of four 14-inch guns
9. Automatic flare lifebuoy
10. Carley floats
11. "B" turret of two 14-inch guns
12. Multiple pom-poms
13. Control tower, bridges and sea cabins
14. Navigating bridge
15. Torpedo director tower
16. Main director tower
17. Secondary armament director tower
18. Main fire control top
19. Tripod mast
20. Signal halyard
21. Wireless aerials
22. Forward port searchlight
23. Multiple pom-poms
24. Carley floats
25. 4.7 high-angle gun
26. Paravane
27. 25-feet whaler
28. Forward port 5.25-inch secondary armament
29. Port aircraft hangar
30. Athwartship aircraft catapult
31-31a. Aircraft and boat cranes
32. Speed boats
33. Shore boat
34. Admiral's barge
35. Aft port 5.25-inch secondary armament
36. Aft port searchlight
37. Aft control tower
38-38a. Secondary armament director towers
39. Aft fire control top
40. Aft main director tower
41. Multiple pom-pom
42. Ditto
43. "X" turret of four 14-inch guns
44. Quarter deck
45. Admiral's stern walk
46. Port inner propeller
47. Port outer propeller
48. Bilge keel

A cutaway drawing showing the general arrangement of the giant snow cruiser. The cruiser is fitted with complete wireless equipment and from this drawing the arrangement of most of the compartments can be ascertained. Note the housing of the aircraft on the back of the giant car and machine shop below control tower.

WORLD'S LARGEST CAR

by BRYAN S. McCANN

LIKE a page from some fantastic story of the future, construction has been going on in America for the past few months on a new mammoth car designed to transport men across the snowy wastes of the Antarctic.

This fifty-five-foot long giant carries on its back an aeroplane capable of carrying five men. Its wheels are ten feet in diameter and it weighs 40,000 lb. It will carry four men, sufficient food and stores to last a year and fuel for 5,000 miles. The aeroplane will, in addition, have a range of 500 to 600 miles.

The machine has been built for the United States Government's projected expedition to the Antarctic. This expedition, due to start shortly, is going to claim for the American Government the land sighted by Lincoln Ellsworth and Rear-Admiral Richard Byrd. Byrd and Ellsworth claimed these vast areas in the name of the American Government and it is now intended that this expedition shall take possession by actual occupation. It will also serve to strengthen American claims to other areas first sighted by American Antarctic explorers.

During recent years, however, other claimants have come forward with reasons why they should also share in the vast Antarctic. These include Great Britain, France, Germany, Norway and Argentine, all countries who are now beginning to realise the actual value of the Antarctic.

Spurred on by these claims, the American Government last year voted a vast sum of money for the development of the Antarctic expedition and this resulted in the creation of a new government department.

At the head of this department—the U.S. Antarctic Service—is Rear-Admiral Richard Byrd, the man who will lead a party of 160 men, colonists, who will inhabit the claimed areas. Each year a new batch of colonists will be sent to relieve their comrades, and so by continual occupation it is hoped to establish a definite claim to the land. At least until an international commission can be set up to settle questions of boundaries and so on.

Why this sudden rush for the wastes of the Antarctic? What is the value of these icy wastes?

Research has proved that underneath the Antarctic there lie coal supplies second only to those at present in the United States. Mineral wealth, too, in the form of copper nickel, tin and oil awaits those who develop these frigid lands. In the future it is very probable that both air and naval bases will be established in Antarctica, short air routes to places all over the world and convenient naval bases are an invaluable asset to every nation. Meanwhile the development of these areas will facilitate the control of the whaling industry.

These, then, are the reasons for the wish to develop what a few years ago were looked upon as merely waste areas, and the "snow cruiser" is the instrument that the American Government will use in substantiating their claim.

The cruiser's pneumatic tyred four wheels are individually propelled. Each has its own electric motor which in turn is controlled by the man responsible for piloting the craft. He is in a position to control combinations of from one to four wheels without so much as having to leave his conning tower.

The cruiser is piloted by one man using hydraulic steering controls and he will be able to steer both front and rear wheels to give the machine a turning radius of only thirty feet.

One of the great advantages that this snow cruiser will have over other previous vehicles used for Antarctic exploration is its ability to overcome the setback of crevasses in the surface of the ice.

Because of a method whereby the giant wheels can be adjusted so that they are able to lift the cruiser as much as four feet off the ground or alternatively let the bodywork slide over the ice, the machine is capable of negotiating a fifteen-foot crevasse with extreme ease and simplicity.

The cruiser proceeds to the crevasse and continues until its wheels overhang the first edge. Then these wheels are raised and the back wheels propel the machine forward until the runners on the front of the machine reach the other side of the crevasse. This is then able to slide forward, the front wheels are lowered and they similarly pull the rear wheels and the back part of the machine across. In previous days of ice exploration a fifteen-foot crevasse may have meant a detour taking many days and adding considerable risk to an already dangerous hazard.

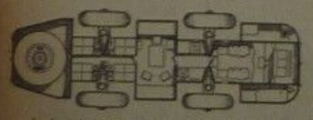
In the snow cruiser there are two Diesel engines which supply the power for the four electric motors; these are in the engine room. There is in addition a 200 amp. capacity set which supplies current for lighting, and the heat for the aeroplane.

Walking from end to end of the snow cruiser, one would first start at the conning tower, right in the nose. The tower is capable of seating three of the crew. Immediately behind it is the navigator's cabin, a form of chart room, from whence four steps lead down to the engine room in which are kept the two Diesel engines, and thence into the combined galley and photographic dark-room. On the other side of the dark-room is the large saloon containing four bunks, a table and four chairs in which the crew are able to relax.

Behind the crew's saloon the provisions are stored and in the extreme tail of the machine there are two spare wheels. The fuel is stored in tanks under the cabins.

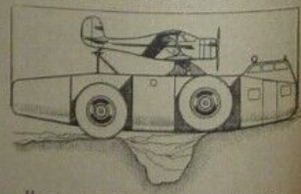
On a level stretch the machine will cruise at 10 or 12 m.p.h. and have a top speed of 25 m.p.h.

The machine is based on the design of Dr. Thomas Poulter, second in command of Byrd's 1933-1935 Antarctic expedition. Dr. Poulter has complete faith in his invention and to prove it he will be one of the crew of the machine, entrusting himself to this moving juggernaut.



A plan of the snow cruiser showing the general arrangement. The position and size of the crew's saloon are noticeable.

Dr. Thomas Poulter demonstrating a model of the cruiser. The size of the giant can be ascertained by comparison with the aeroplane above it.

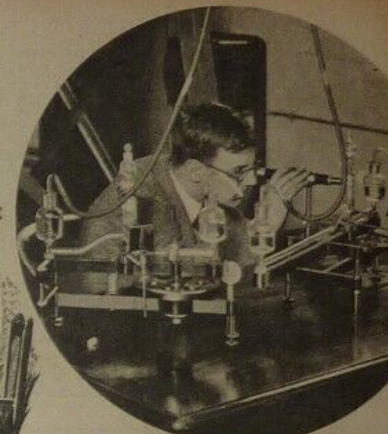


How the snow cruiser crosses a crevasse. By being able to lower or raise each of the wheels individually the machine can easily cross these crevasses.

ALCHEMIST
Yesterday and Today

THE MAGICIAN OF YESTERDAY HAS GIVEN PLACE TO THE CHEMIST OF TODAY

by B. TONBRIDGE



Modern chemists carry out experimental work which is of great assistance to industry. In this picture liquid gauges enable accurate measurement of air speed in a wind tunnel.

WHO hasn't dreamed of new lamps for old," burnished gold for rusty iron? It is a dream that men have held through the centuries, and many have devoted their lives to the study of the seemingly impossible.

In ancient Greece the forerunners of our modern scientists thought that it should be possible to convert one thing into another. Because gold and silver were the most valuable of metals, they claimed to have discovered the means for converting the everyday, cheap metals into the precious ones which have represented wealth from earliest times.

From one civilisation to another, this pretended art was passed down, until when it reached western Europe the realization of the age-old dream had become almost an obsession with chemical workers. If all the time put in by the early chemists in pursuit of this fleeting dream could be added together, it would look as if mankind is prepared to waste any amount of time in an effort to get rich quick.

But fortunately for the memory of those early experimenters their hard work and patience, although never rewarded in the way they hoped, has given their descendants a basis for the science of modern chemistry. Their dream of turning iron into gold was based on superstition, but the experiments they made in an attempt to achieve their object taught them a great deal about the chemical relationship of various substances, so that later generations have learnt to convert some things into others.

Systematic chemistry grew from the magic art of the old-time alchemists, the origin of whose studies is wrapped in numerous legends. Some say that the Egyptian god Hermes passed it on to his devotees. Whether this is true or not doesn't much matter, but it is true that some of the early alchemists described their experiments as "hermetic art," and placed the seal of Hermes on their returns. From this custom the phrase "hermetically sealed" has been adopted into our language.

The knowledge of this pretended art appears to have been chiefly vested in the priests of the time, and they seem to have achieved quite a lot of success in making their people believe that they could really make gold and precious stones. Their probable real chemical knowledge was confined to their ability to gild metals, which to those not in the secret would seem as if supernatural powers were given to the priestly alchemists.

But although the early experimenters practised certain tricks to deceive their more credulous countrymen, they also put in a great deal of valuable work. Ideas were very jumbled. Mankind had few theories on the relationship of matter, or even of his own position in the world in which he lived. In devoting attention to the conversion of the baser metals the alchemists started to think and work along lines we now call scientific.

During the sixteenth century alchemy took a new twist. No longer was it the object of the chemists to make gold, but their new aim was to prepare medicines and assist the work of the doctors. This lead to the study of the properties of substances, and with medical interest working in combination with the chemists some of the best brains of the time were soon concentrated on what was rapidly developing into the science of chemistry.

The seemingly wasted work of the alchemists had resulted in three important items of information being available about metals. It had been discovered that some metals when heated strongly in air were converted into what we call oxides. When this oxide was formed there was an increase in weight. Then, that other metals like iron produce sulphides when heated strongly with sulphur in a closed space.

This and other information that had been learnt on metals made a basis for chemical study, although until the eighteenth century very little actual progress was made in practical metallurgy. During the seventeenth century scientists began to formulate theories on such subjects as gases, and the hand of progress began to guide the minds of the chemists to enable them to speculate on the knowledge they already possessed.

Farming is one of the industries which has derived many benefits from the work of the chemists. Samples of soil are here being tested to discover what chemicals they lack.

All sciences have been built up a step at a time. Chemistry is no exception. The wonderful synthetic substances which can be manufactured from the most unlikely seeming materials are possible as the result of the rapid development of the chemists' research.

The real science of chemistry started when Robert Boyle went to Oxford to carry out experimental research. The results of his work led him to question a number of statements that had been looked upon as facts, and a start was made at believing only that which could be proved.

Such great men as Black, Cavendish, Priestley and Lavoisier emerge from the early years of chemistry as a science, whilst in 1803 Dalton published his first list of atomic tables. By 1828 discoveries had been made in connexion with organic chemistry and the question of preparing substances synthetically began to be studied.

Previously chemists devoted their attention to the study of metals and minerals, but with the discoveries connected with the carbon compounds, scientists took into their range of vision all the substances of animal and vegetable origin.

The study of all these carbon compounds is so wide a subject that in modern chemistry it is a separate branch on its own. Carbon is peculiar, inasmuch as it is capable of combining with a large number of elements, as well as combining with itself to an unlimited extent. The value of the development of organic chemistry to mankind is reflected in the ability of the modern scientists to make, synthetically, substances which have previously had to be obtained in their natural form, thus supplementing the world's stock of raw materials.

Amongst the most important results of the work of the chemists has been the way in which they have shown industry how to make such necessary products as dyes, medicines, perfumes, flavours and cosmetics all from coal tar. The chemists have taught industry not only to make one thing from another, but also to avoid wastage of by-products.

Modern chemistry has its finger in every pie. It assists the law to catch criminals. Analysis reveals many things that clever rogues hope may never see the light of day, and most police forces have a staff of chemists whose job of scientific deduction assists detectives to lay a crime on the head of the guilty man.

No less important is the work of the chemist in the field of agriculture. Chemical fertilizers are essential to intensive crop production, and salts which build healthy plants must be supplied to the soil, if lacking. Without insect- and fungus-destroying chemicals crops would be ruined, whilst fruit ripening and storage has been greatly improved through the scientific knowledge supplied from chemical research laboratories.

One of the greatest problems which men of science have to face is that their work, which has been aimed at benefiting humanity, is diverted into paths which destroy it. In their search for new knowledge they release forces for which the world seems yet unprepared. Chemists often come in for a great deal of criticism for this reason. In producing chemicals for our progress they have created the very instruments that destroy us.

And yet very few of the high explosives or poison gases were produced with the object of destruction. Most of them had peaceful uses which have been diverted to sinister wartime objects. Explosives are essential to such peaceful occupations as mining and engineering, and the gun-cotton that charges the deadly torpedoes is a near relation to the collodion from which our earliest artificial silks were made.

Some of the poison gases, which today bring so much suffering to the world, have valuable uses in agriculture and for killing bacteria. Even the chemists' necessary bombs which cannot be spared for their military use to the engineering practice of using a mixture of iron oxide and aluminium powder to weld steel when oxy-acetylene apparatus was not available.

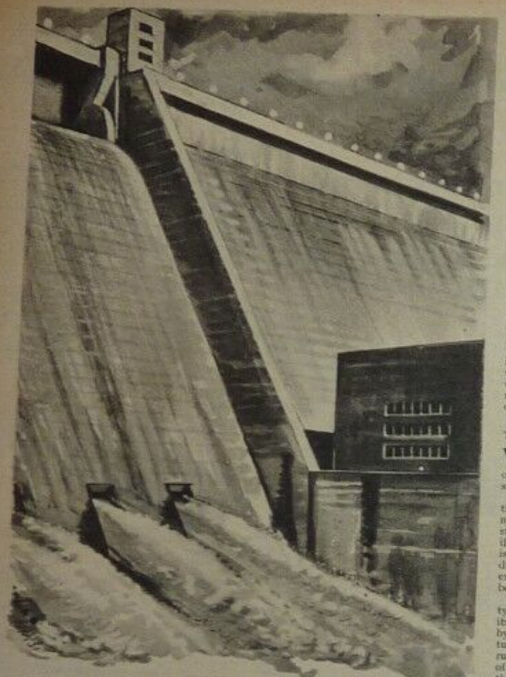
Amongst the latest chemical wonders are those which make it possible to produce better coloured photographs. New organic chemicals of a very complicated structure have been made which make it easier to sensitize the emulsion used on films, and also give correct colours in the finished pictures.

New processes have been evolved by the chemists so that natural gases can be converted into high grade motor spirit, and a wide range of substitute materials are making warring nations more dependent on the work of their scientists than ever before. Recent news from America tells of a new synthetic rubber, which made up in the form of shoes has a wide range of uses for such things as clothing.

Every moment the work of the chemist continues. From the humble janitor of the early alchemists there now has been developed to exploring the wonders of the earth. The forces which their knowledge unlooses are a colossal feature in the happiness of the world; the misdirection of their knowledge may yet destroy us.

STEEL PLATING

A three-inch jet of water cannot be broken by a sledgehammer – such is the amazing power of harnessed water, which is the life's blood of our modern industries



One of the tributary dams in the Tennessee Valley, the dam at Norris. Down the slope great cascades of water pour at full flood to operate turbines.

EIGHTY-SEVEN thousand cubic miles of water are evaporated by the sun from the seas and lakes of the world every year, or so the scientists tell us.

This is just as surely returned to the earth again in the form of rain or snow, to pour back into the ocean through the rivers, fast or slow, according to the nature of the country upon which it fell. Moreover, the sequence has gone on since the earth's crust first solidified, more than a thousand million years ago. It is responsible for the fact that there is kindly soil over much of the land on which we are able to grow the food we need.

With this side we are not immediately concerned, except in this, that it was to get their corn ground with the minimum of labour that men first cast eyes upon the ever-flowing rivers and streams as a possible source of power. Water power is a great boon to those countries where it is available, but it is enormously expensive to develop.

Nature has been curiously just in some respects, for bountiful water power is to be had in places where natural supplies of fuel are scarce.

Let us see what sort of conditions are necessary for such development. In the first place, the water must be flowing; the more the better. As this is the first requirement, the main supply must be at a greater height than the point at which we want to use it. Water power is not economical of water! Consider one of those cubic miles of which we spoke in the first paragraph. How big a lake, or reservoir will it fill, and how long will it work?

One cubic mile of water represents a reservoir one hundred feet deep, one mile wide and fifty miles long—a very respectable lake altogether. What this will do for us depends entirely upon how high up in the mountains it is situated.

Suppose that it is five thousand feet up. We are fortunate indeed, for we can have a thousand horse-power continuously for a thousand years before such a supply is completely drained! But with such facilities we should look for a greater output of power, were any such available. Let us be more reasonable and imagine our lake much lower down, say at four hundred feet above the power station.

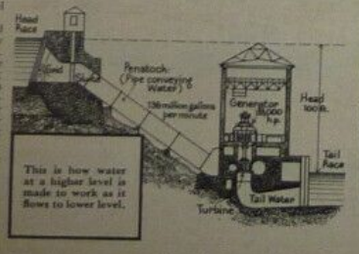
NATURE'S LIMITATIONS

To give us one thousand horse-power we should have to run about one thousand seven hundred cubic feet through our turbine every minute, if it is an efficient one, and that will drain the reservoir in a matter of a hundred years. Good enough in all conscience, one would think.

A power station developing no more than one thousand horse-power would not be considered as more than a small affair, such as would provide the power requirements of a moderate-sized factory today. What we should reckon a big station is one that can turn out anything over half a million horse-power continuously, and there are those capable of more than this in various parts of the world.

To give five hundred thousand horse-power our big lake would run out in two years, probably much less. There are very few water power installations in the world using a head of five thousand feet, however, for Nature has not been quite as bountiful as that.

These figures are quoted to give some idea of the power available in flowing water. Water has weight, and it flows with perfect freedom, though it strongly resents any attempt to alter the direction of its flow, just as every moving body does.



TYPES OF WATER TURBINES

Water turbines are of two main classes, one designed to deal with large volumes of low-pressure water, and the other with small quantities of high-pressure water.

The first principle to be understood is that of pressure. If our storage is not very much above the height at which the power station is built, then the pressure is low; if it is well up in the hills, then the pressure is high. Hydraulic engineers refer to this difference in height as the head, and the extent of it governs the type of turbine to be employed.

On these pages are drawings of three types of reaction wheels, one complete in its casing. Observe that the water enters by way of a spiral passage, encircling the turbine. Before it can get through to the runner, it must pass by way of a number of guide vanes, and the openings between these vanes can be altered from full to completely shut, because they are pivoted something like doors on their hinges. In this way the speed can be controlled to a nicety by centrifugal or other governing devices.

Passing through the guide vanes of the gate, the water enters the vanes of the runner, and these are made of a progressively curved shape to provide resistance to the straight flow of the stream. In the sketch water is shown as falling vertically, and this is the usual arrangement for big sets, but is not universal.

When the water first enters the turbine it is travelling tangentially, and the blades are shaped at the top to take advantage of this. Immediately after, it commences to fall vertically into the draft tube through which it escapes to the tail race, and in this vertical fall it meets a differently shaped part of the blade, designed to secure rotation from the reaction as the water flows out. This is the Francis runner.

The second type of runner is the Kaplan, and is easier to understand. Its blades are formed like those of the ship's propeller, but their pitch can be varied, so that they present a different angle to the falling water according to the power requirements.

A runner of this sort handles falling water entirely, and has no part of its blades designed to deal with the tangential flow, though controlling gates are provided, of course.

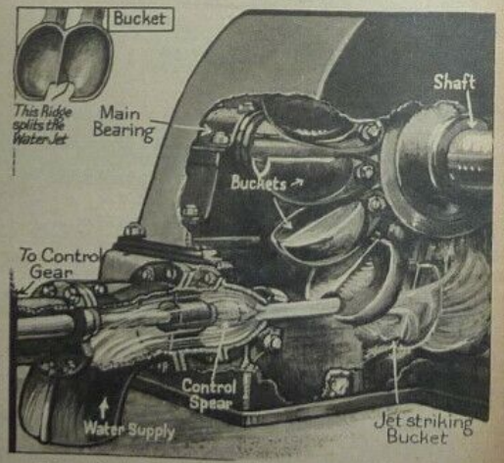
In the U.S.A. they have embarked upon huge schemes to control the flow of the great Tennessee River and to keep it in some sort of order. This has been done by building large dams, thereby impounding great volumes of water, which are released by way of water turbines into the next stretch below, only to meet with similar conditions farther on.

GLACIERS FEED TURBINES

Over a distance of about six hundred miles there will be nine of these dams on the main stream, four of which are completed, and at least two others on tributary rivers.

So much, then, for the reaction type of turbine; we must now see the impulse variety. These are the water wheels proper, the true descendants of the old water mills set in the stream, though it must be admitted that they bear little resemblance to them.

It does not need any great thought to understand how they work, for all we have is a jet of water made to strike buckets of water fixed round the rim of a wheel. This is the Pelton wheel turbine, and its use is increasing, especially in countries like



This type of turbine is operated by a jet of water striking the buckets on a wheel. Water flow is controlled by a spear-shaped piston. A ridge in the buckets splits the jet into two.

SMASHED by Water Jets!

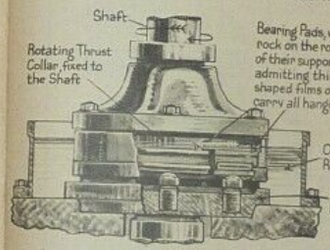
Sweden, Norway, Switzerland, Japan and elsewhere; places where melting snows and glaciers feed mountain lakes continuously.

A dam can be constructed to provide extra storage water if it is needed, and it may well be so in times of drought. After this a steel pipe line has to be built to carry the water down to the power house below, which must be on the banks of a river. This is obviously to carry away the large quantity of tail water from the wheels.

WATER JET LIKE STEEL

Pipe lines are expensive, and have to be massive in construction, as they must be heavily anchored to the mountain side at intervals. Bends are unwelcome, so if it is possible, a perfectly straight stretch with an even gradient is selected. To supply the requirements of a single turbine requires at least one pipe, according to the head.

At Fully, in Switzerland, one pipe only twenty-one inches in diameter supplies one turbine in the power house five thousand



Part section of a Kingsbury bearing which is used to take a hanging load of 250 tons, rotating at 100 revolutions a minute.

three hundred and twenty feet below, but that turbine develops no less than fifteen thousand horse-power! The water emerging from the small jet at the bottom is travelling at thirty-five thousand feet per minute, and is like a forged steel bar, for you could not break it. Its pressure is about one and a half tons to the square inch, and it is no more than one and a half inches in diameter.

This jet strikes the buckets bolted to the rim of the wheel, driving them before it at a speed of eighteen thousand feet per minute, just over half its own speed. No, the wheel speed is not equal to that of the jet. If it were so, no power would be developed, which sounds queer at first. A wheel travelling at the same speed as the water jet is offering no obstruction or resistance to it, therefore no work is being done upon it. At half the speed, or thereabouts, conditions are at a maximum.

The other drawing shows the jet striking the buckets of a wheel, it shows how the buckets are divided by a sharp-edged ridge into two halves. This sharp edge divides the jet equally into two.

To control the flow of the water, a spear-shaped piston is pushed slowly into the orifice from inside, by the governor. This has to be done slowly, for a quick movement sets up enormous stresses in the pipe line.

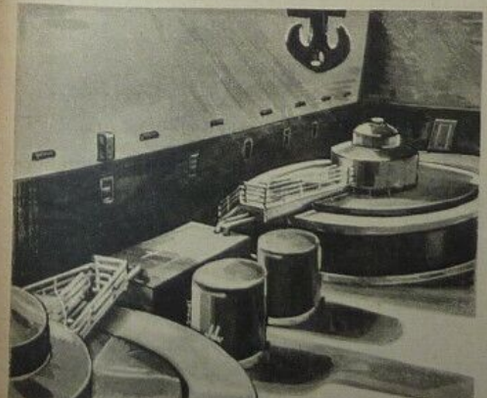
To stop the wheel quickly in the event of a sudden cessation in the electrical load, such as might be caused by the breaking of the overhead power lines, the jet can be deflected to shoot clear of the wheel buckets. If this were not done, the wheel would run wild and maybe burst itself through the enormous centrifugal force generated.

Here in Great Britain we are not so well blessed with facilities for power of this sort. Only in the mountains of Wales and Scotland, where there is a good rainfall, have we any development to speak of.

BRITISH WATER POWER

In Wales, and in the Grampians of Scotland, a contribution is made to the public supplies through the Grid. Perhaps the biggest undertakings are those put through by the British Aluminium Company in the Western Highlands, where they produce aluminium. This process requires large quantities of cheap electricity for the furnaces, and once the installation is set up, the current is cheap. Not, of course, however, if the cost of the necessary tunnelling is all charged up to the work at once!

The power house at Fort William is supplied from Loch Treig, eight hundred and sixty feet above, by a tunnel fifteen miles long, cut through the heart of Ben Nevis, then by a twin pipe line down the side of the mountain to the turbines at its foot. The combined storage of water in Lochs Treig and Laggan amounts to about



The interior of a modern water power house. The 45,000 h.p. generators at Pickwick in the Tennessee Valley scheme.

ten thousand million cubic feet, and this will keep one hundred and twenty thousand horse-power going.

The pipes, of which there are two, are sixty-five inches in diameter, three thousand two hundred feet long, and have welded joints. This work was done on the site.

The best low-head installation in Great Britain is the River Shannon scheme in Ireland. Our diagram on those pages illustrating the head is drawn from one of the power stations at Ardnacrusha. When the full scheme is working, about one hundred and eighty thousand horse-power will be available, but about ninety thousand horse-power is taken at present, generated by three turbines.

WATER MAKES ELECTRICITY

On the diagram we have marked the head as one hundred feet; maximum possible is one hundred and ten feet, and the minimum (with normal flow) is eighty-six feet. This makes a considerable difference in the output of power. At maximum head and flow, the power is thirty-eight thousand six hundred horse-power from each turbine, but at minimum it is only fifteen thousand five hundred horse-power. Current from Ardnacrusha is distributed all over the Free State, by 110 k.v. lines to Dublin, and by lower pressure as far north as Sligo and Dundalk.

Early Persians are reputed to be the first to have set paddle wheels in the flowing streams, and the moving water turned them round. To make our electricity to keep the wheels of industry moving, we do the same. But what paddle wheels they are!

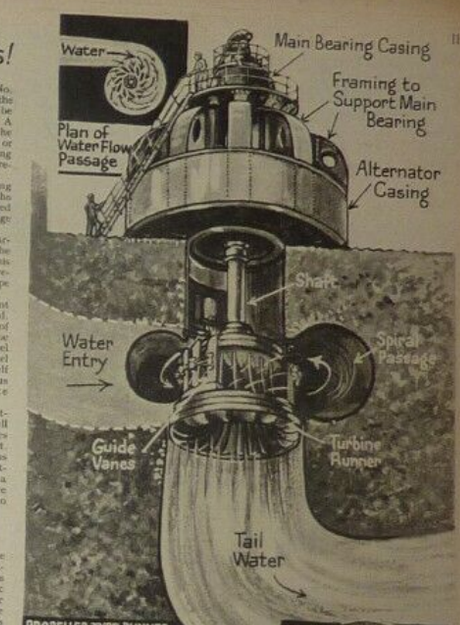
Some of them are as much as twenty-five feet in diameter, and move only slowly. But from their sixty revolutions of somewhere around forty-five times a minute we get forty-five thousand horse-power an hour. The rushing water supplies the motive power to keep our turbines running for weeks on end.

Then there are fast ones, those that revolve up to four hundred times a minute. They are driven by water jets that travel at thirty-five thousand feet a minute, a figure that in feet may not sound much, but when reckoned at six and a half miles becomes really formidable.

Of the two kinds of turbine the greatest share of the work is done by the low-head installations. This is because the flow of big rivers can be controlled to give the low-head supplies, and it is also more economical to generate electricity in single machines of large output.

One thing has to be remembered in connexion with water power. We can never hope to absorb the whole of the energy available. For this reason means has to be provided to run off water as soon as it has done its work.

The value of water power is its ability to be transformed into electrical energy. Direct driven machinery, like the old-fashioned corn-grinding mills, is not required for modern industrial purposes. But with cheap electricity, power machines are able to do their work



Water enters the reaction wheel by way of a spiral passage and passes through guide vanes before getting through to the runner. This illustration shows how water is converted through a turbo-generator into electricity so essential to industry.

THE GERMAN AIR FORCE

ON these pages we illustrate twenty types of planes used by the German Air Force, and above and below are shown the silhouettes the view most often seen by observers on the ground.

No. 1.—Junkers "J.U.87." 240 m.p.h. dive bomber. A shows compact engine; B, mounting for heavy bomb; C, fixed machine guns; D, wing leading edge slots; E, fuselage construction; F, rear machine gun position.

No. 2.—Heinkel "H.E.112." Single-seater fighter; speed exceeding 300 m.p.h. A is one of two fixed machine guns; B, retracted landing wheel; C, one of two petrol tanks; D, small bombs; E, air intake.

No. 3.—Heinkel "H.E.111K." Medium bomber, top speed 262 m.p.h.

No. 4.—Dornier "D.O.17." Fast medium bomber; 295 m.p.h.

No. 6.—Henshel "H.S.126." High wing reconnaissance monoplane with speed around 220 m.p.h.

No. 7.—Messerschmitt "109." 354 m.p.h. monoplane fighter, having four fixed machine guns in wings and quick-firing cannon through propeller boss.

No. 8.—Messerschmitt "110." Four-engined fighter bomber with four machine guns and two cannon.

No. 9.—Henshel "H.S.123." Single-seater biplane fighter of older type.

No. 10.—Arado "A.R.80." Metal constructed fighter monoplane.

No. 11.—Blohm and Voss "H.A.137B." Two fixed machine guns on fuselage, or sometimes cannon. Speed 210 m.p.h.

No. 12.—Heinkel "H.E.118." Bomber-fighter with four machine guns in wings, and one in rear turret.

No. 13.—Dornier "D.O.19." Large four-engined bomber. Not very fast, about 200 m.p.h., but carries heavy load of bombs.

No. 14.—Three-engined commercial type with speed of 180 m.p.h.

No. 15.—Junkers "J.U.89." Four-engined plane with speed of 220 m.p.h.

No. 16.—Dornier "D.O.18." Flying boat that used to be catapulted from German transatlantic liners for mail deliveries.

No. 17.—Blohm and Voss "H.A.140." Seaplane used as a bomber and for torpedo dropping and general reconnaissance work. Speed 200 m.p.h.

No. 18.—Dornier "D.O.22." Seaplane for torpedo dropping and reconnaissance. 225 m.p.h.

No. 19.—Dornier "215." Improved model of "D.O.17," having speed of 320 m.p.h.

No. 20.—Heinkel "H.E.170K." Bombing reconnaissance craft with maximum speed of 265 m.p.h. Two fixed machine guns, and two machine gun turrets.

Drawings and silhouettes on these pages are not drawn to scale.

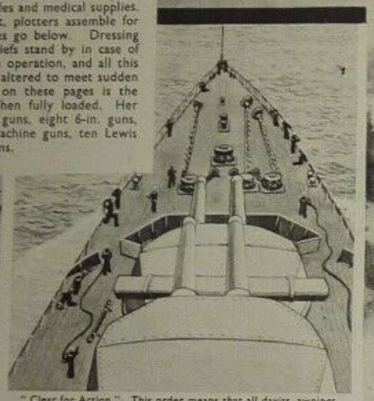
Action Stations!

"ACTION stations" may be ordered at any time of the day or night in a British battleship in wartime, and what follows is a marvel of organization and administration. Every man has an allotted station, and he doubles to it at once, leaving anything that he may be doing.

Writers and paymasters must leave their ledgers and accounts, all davits, awnings and rails, etc., have to be lowered, magazines opened up, control tops and spotting platforms aloft and torpedo flats below have to be occupied; surgeons and doctors have to prepare operating tables and medical supplies. Anti-gas squads are formed, note-takers run about, plotters assemble for the guns, fire-fighters get busy and collision parties go below. Dressing stations are formed and gun turrets manned. Reliefs stand by in case of casualties. Emergency electrical circuits are put in operation, and all this organization must not be so rigid that it cannot be altered to meet sudden emergencies. The ship shown going into action on these pages is the recently reconstructed *Warspite* of 35,000 tons when fully loaded. Her crew numbers 1,124, and she carries eight 15-in. guns, eight 6-in. guns, eight 4-in. A.A. guns: four three-pounders, five machine guns, ten Lewis guns, multiple machine guns and multiple pom-poms.

A pretty tough nut to crack, Mr. Hitler!

In a salvo only one gun in each turret is fired while the other is reloading. A broadside is a discharge from all the large guns that can bear on one side. One from the *Warspite* weighs 13,400 lb.



"Clear for Action." This order means that all davits, awnings, stanchions, ensign staffs, hand rails and so on have to be lowered. Hoses are also run along the decks ready for fire fighting.

The dotted lines represent the system of intercommunication between control top, gun turrets and transmitting room. The sequence of operations is as follows:

1. Position of target and ranges from control top and gun turret are sent to transmitting room.
2. Mean range is re-transmitted to control top.
3. Training and elevating directions are then given to gun turret. Guns have been loaded meanwhile.
4. When guns are ready signal lamps show in transmitting room.
5. Control top is informed and director-layer fires the guns by electrically connected pistol.

(Left) Orders are flow given by loud-speakers situated throughout the ship, also telephone communication is used and triplicated.

Above is a typical "fire control" telephone switch.

(Above) The main switch-boards control the distribution of electrical power. Also several emergency ones. All are protected by the main armour belt.

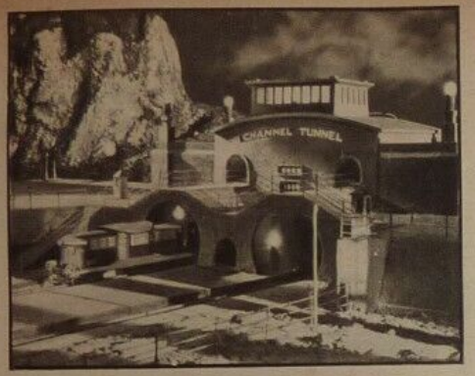
(Left) When in action the lower conning tower is manned, and if the fire is "too hot" above, the ship is controlled from here. Again well within the main armour belt.

The movements of the enemy are followed from the compass platform by means of binoculars fitted with special sights.

ASWill WOOD

Key to numbers on warship.

1. Director tower
2. 6-in. armour
3. Expansion tank machinery
4. Director-layer
5. Rangefinder
6. Secondary armament range-finder
7. Remote control office
8. Compass platform
9. Admiral's bridge
10. 14-in. armoured conning tower
11. Watch office
12. Signal officer
13. Signal house
14. Signal platform
15. Stairs
16. Petty officers' reading room
17. Admiral's bathroom
18. Admiral's sea cabin
19. Watch officer's cabin
20. 4-in. armoured communication tube to lower conning tower
21. Lower conning tower
22. Medical stores
23. Transmitting room
24. Boiler room
25. Torpedo bulge
26. 13-in. main armoured belt
27. 27a, 27b. Port 6-in. secondary armament
28. Twin 4-in. anti-aircraft gun
29. Rangefinder
30. 11-in. armoured gun turret
31. Turret machinery house
32. Roller bearings for turret
33. 10-in. armoured barbette
34. 6-in. armoured belt
35. Torpedo bulge
36. 13-in. main armoured belt
37. Ammunition trunk
38. Cordite magazine
39. 15-in. shell magazine



Will there ever be a CHANNEL TUNNEL?

£60,000,000 PROJECT THAT WILL HELP TWO GREAT NATIONS

IN 1924 and again in 1930 the British Government had the opportunity of providing a safe passage between this island and France. French co-operation was offered to construct a tunnel under the sea of the Channel, but military bigwigs seriously opposed such a scheme as rendering this country vulnerable to invasion. Had their decision been different it would have been possible to transport men and munitions far more safely, to the battlefields of France, in 1940.

Over a century has passed since the idea of constructing a tunnel under the bed of the Channel was first suggested. In the days of Napoleon, 1802, to be exact, an engineer by name Mathieu, made the proposal. At that time it was suggested that the construction of the tunnel should be embodied as one of the terms in the treaty between the Allies. But before this could be put into effect, England and France were at war, and this, of course, squashed the idea for the time being.

After France had been defeated in 1870, interest in the scheme revived. By 1874 plans had not only been completed, but actual construction was started, and pilot borings were made on each side of the Channel, for short lengths. Military experts at that time, also, were against the scheme, and by 1882 the contemplated easy route between the two countries was once more just a dream. Towards the end of the Great War the project was again revived, but heavy expense this time ruled it out.

With England and France once more allied against a common foe, the value of such a tunnel is coming to the fore. This time it is the military experts who realize how valuable it would prove for transporting the needs of a mechanized army. The war is costing the two countries over six million pounds a day, and if it could be shortened by even a fortnight, the colossal cost of an undertaking as big as the construction of a tunnel road and railway under the Channel would be paid.

But its value in times of war isn't the sole consideration for the building of the Channel Tunnel. In peace time the increase in passenger and goods traffic between the two countries, it is estimated, would show a profitable investment on the capital involved, to say nothing of the big boost to export and import trade.

One good thing seems to be rising from this war. Economic and industrial co-operation between England and France is developing in a way that is bound to have a great influence for good on the lives of the two peoples, and ultimately on the rebuilding of a peaceful Europe. Already the French Minister of Public Works has named the Channel Tunnel project as one of the major schemes to be started as soon as peace is restored.

Whilst a project of this magnitude would test the skill of experts, it isn't outside their powers in these days when the construction of tube railways under cities has provided a vast fund of experience in overcoming difficulties. Naturally, a scheme of this kind has a number of different methods suggested for its accomplishment. Methods of carrying out the task have been estimated to cost anything from twenty to sixty million pounds. But on at least one point the majority of experts seem to agree. Most schemes would make the passage of the tunnel under the sea laid as short as possible.

At their nearest points the distance between the two coasts is only about twenty miles, and the suggestion is advanced that gradual slopes at each end, starting at points ten miles inland, would enable traffic to descend easily to the maximum depth below the sea, variously mentioned as 150-300 feet.

From the work of the early Channel Tunnel exponents there still remains quite a lot of useful data to assist the experts in the work of construction. Over seven thousand soundings were made for testing the strata of the Channel bed, and shafts sunk on both sides of the water have proved that the nature of the layers of earth provide no insuperable barriers to the work. Easily workable chalk would make operations comparatively easy, it is claimed, for most of the distance.

Somewhere about the centre of the Channel some experts consider glacial strata will be encountered, and this part of the task will naturally prove more difficult. Centuries old glacier rocks will make a tough boring proposition, but even then those who should be in a position to know consider that the job can be accomplished.

If and when construction is properly commenced boring will probably be started from both ends at the same time, which will eventually meet in the middle. At first only a small-bore pilot tunnel will be made. From this, diamond drills will enable the engineers to obtain specimens of the surrounding strata, and it will be possible to inject cement into any porous soil that may require it.

The pilot tunnel serves a number of useful purposes before the main job of construction is started. Along its sides galleries are built from which miners work on enlarging several faces of the tunnel at the same time. Modern scientific methods have shown the engineers how to overcome the great obstacle of seeping water. The difficulty of boring under the surface of water prevented the building of a tunnel under the Thames from its first commencement in 1799 until new methods devised by Brunel enabled him to triumph in 1843.

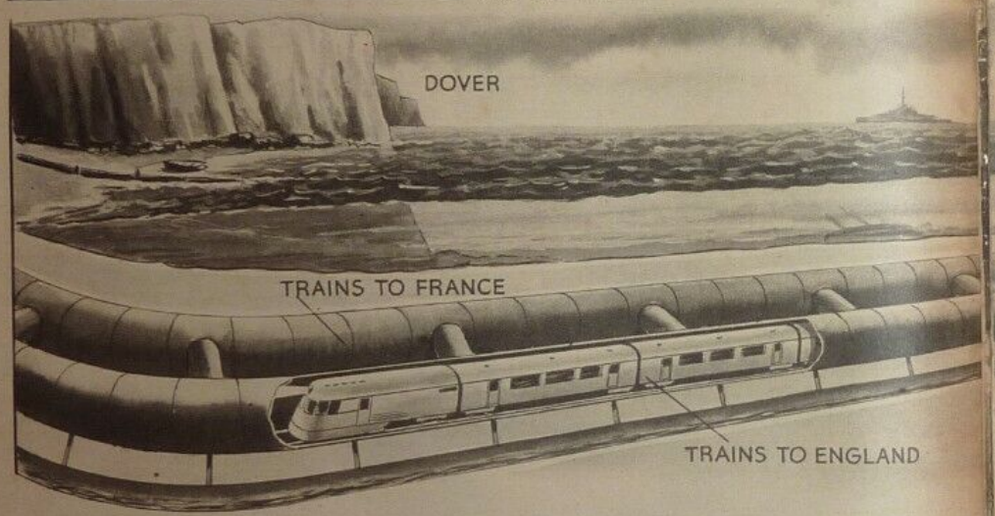
By watching a timber worm burrowing into a piece of hard oak he got the idea of a revolutionary machine that allowed miners to scoop out the soil as they worked in chambers which advanced as work progressed. Bricklayers then followed on and completed the work of building the tunnel.

In those days there was no compressed air, or the other clever ideas which now enable the engineers to keep water at bay. Nowadays squelchy strata can be hardened by chemical methods, and water can be frozen as it collects. Experience gained in driving shafts through water-logged soil has taught the experts many tricks that would prove invaluable in constructing such a vast undertaking as the Channel Tunnel.

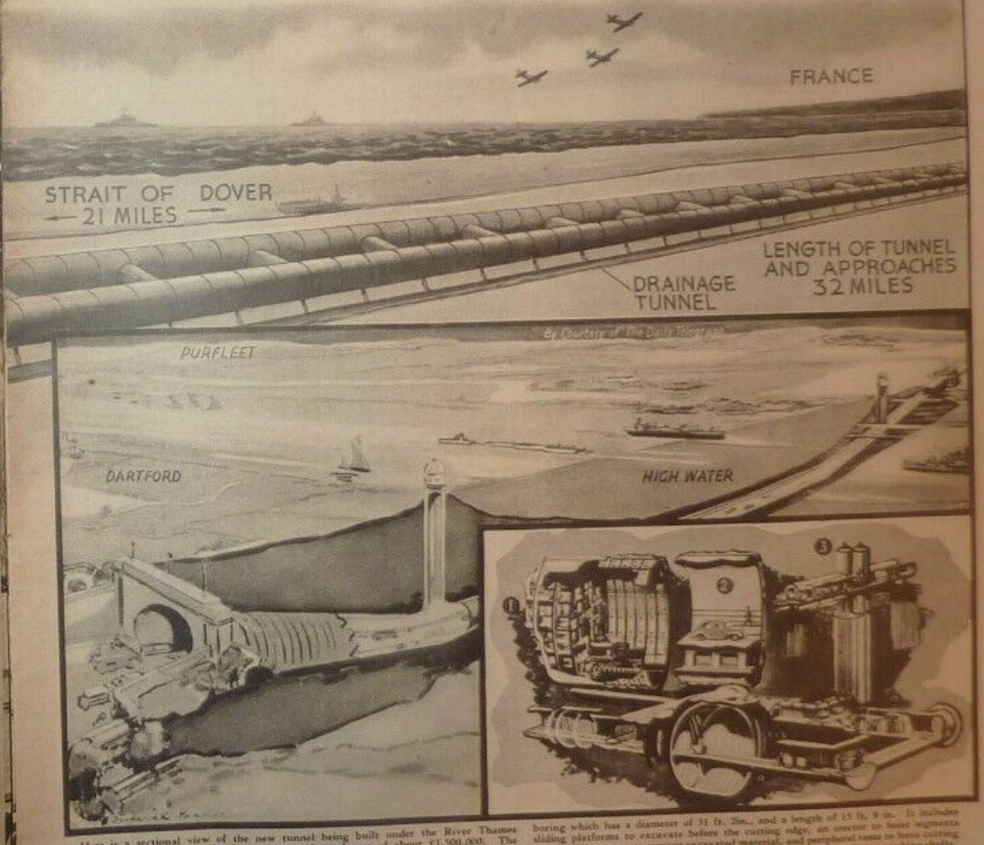
We can get an idea of the work that has already been done by the tunnelling engineers when we realize that the under-sea portion of the Channel Tunnel would be under double the length of the famous Simplon Tunnel. Nearer home there is the magnificent engineering feat of the Mersey Tunnel, which links Liverpool and Birkenhead. Mersey Tunnel is the largest circular tunnel in the world, having an inside diameter of forty-four feet. It is lined with cast-iron plates and concrete, and provides a roadway for four lines of traffic, as well as two pavements.

At its deepest point it is 170 feet below high water mark, and has a wonderful ventilating system, the plant for which is housed some distance from the tunnel. One hundred and ten thousand tons of cast iron were used for the lining, and one hundred and fifty thousand cubic yards of concrete went to the making of this £6,000,000 tribute to the skill of our engineers.

Certainly at the juncture in the history of France and Britain a Channel Tunnel would solve many problems, and if present intentions are carried out we may see one built as a result of the close co-operation between the two countries.

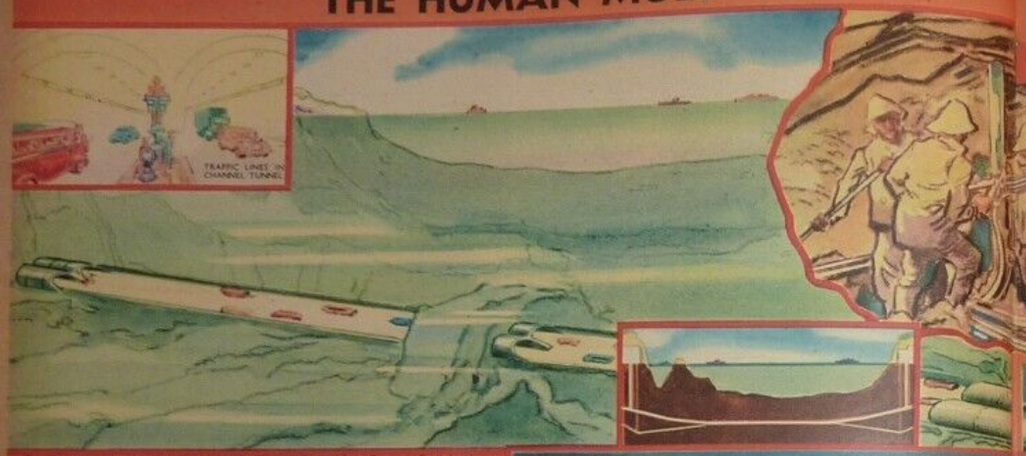


In constructing the many miles of tunnels needed for London's underground railways, steel and concrete are used in very large quantities. After the tunnel has been built the long rails have to be laid. A special chamfered joint is used to connect them together.

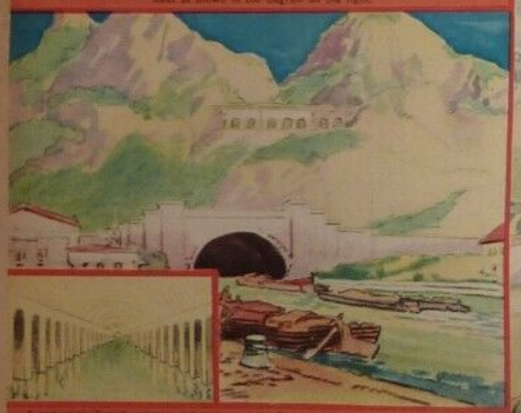


Here is a sectional view of the new tunnel being built under the River Thames from Dartford (*left*) to Purfleet, at an estimated cost of about £1,500,000. The main vehicular tunnel will have a diameter of thirty feet, and the distance from bank to bank at this point is 2,832 feet. Inset are seen 1, the circular shield used for boring which has a diameter of 31 ft. 2in., and a length of 15 ft. 9 in. It includes sliding platforms to excavate before the cutting edge, an erector to hoist segments into position, trams to remove excavated material, and peripheral rams to force cutting edge into ground. 2. The finished tunnel. 3. The vertical shaft leading to working shafts.

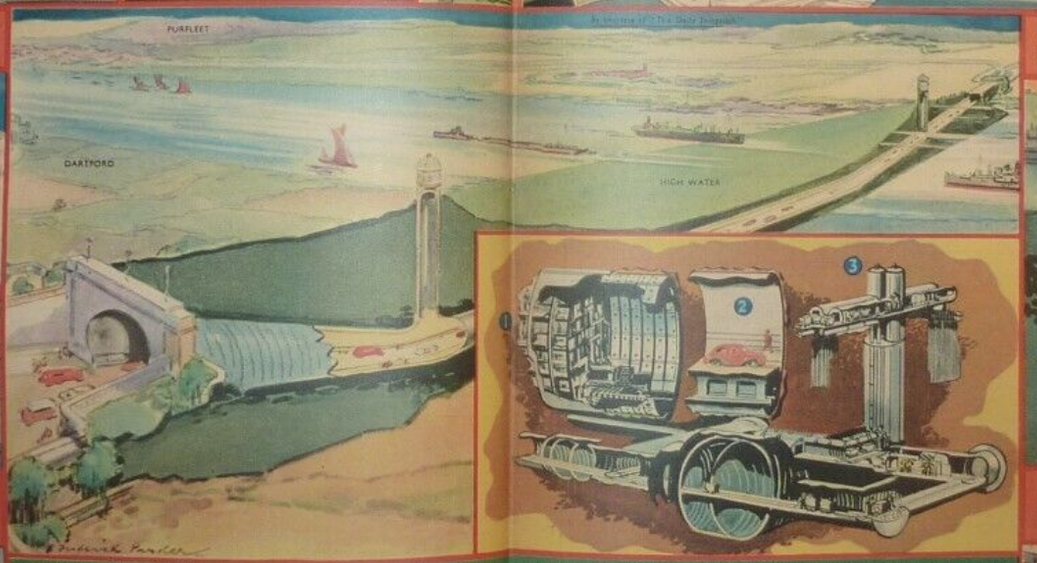
THE HUMAN MOLE



For many years, the idea of a tunnel running under the Channel from Dover to Calais has been mooted from time to time, and although several attempts have been made in the past to launch the project, they have proved abortive. One of the latest schemes is for a double-track road tunnel with powerful lifts to take cars up and from the entrances on the English and French sides as shown in the diagram on the right.

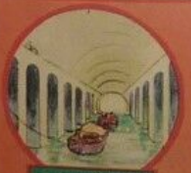


A remarkable French underground waterway is the Rove tunnel, the seaboard entrance to which is at the little port of La Lave, near Marseilles. A little over four and a half miles long, a notable feature is the masonry piers spaced some 7 or 8 feet apart, and at the top of which run the towpaths. Which a width of 72 feet 2 inches, and 30 feet 3 inches high from invert to crown, it can take vessels with burdens up to 1,200 tons.



Sectional view of the new tunnel being built under the Thames from Dartford (left) to Purfleet at a cost of about £3,500,000. It will be ready for use in 1941, and it is hoped that the boring of the pilot tunnel will be finished by next September. The main vehicular tunnel will have a diameter of 30 feet, and the distance from bank to bank at this point is 2,832 feet. Inset is seen 1, the circular shield used for boring which has a diameter of 31 feet 4 inches and a length of 15 feet 9 inches. It includes sliding platforms to excavate before the cutting edge, an erector for lower segments into position, trams to remove excavated material, and periscal jumper forces cutting edge into ground. 2. The finished tunnel. 3. The vertical shaft leading to working chalks.

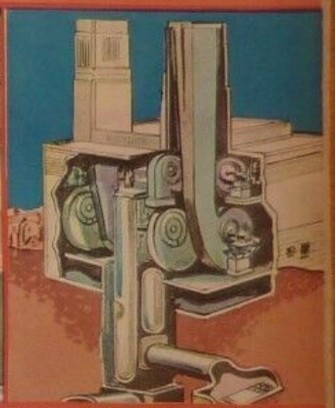
The tunnel of the St. Gothard railway is 9,786 feet above sea-level, but the Simplon western locomotives of 8,500 h.p. make light work of the climb, hauling trains of 400 tons up the inclines at 40 miles per hour.



Europe easily holds the record for the world's longest railway tunnels, and many of them are an enduring tribute to her engineers. Switzerland and Italy share the greatest one in the Simplon tunnel of 12 miles 562 yards, after which comes the Appenine in Italy measuring 11 miles 866 yards. This is followed by the St. Gothard in Switzerland

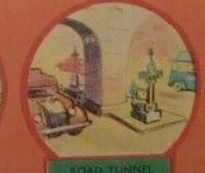
TUNNELLING UNDER LAND AND WATER

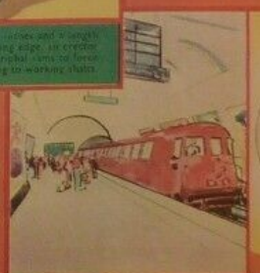
Tunnellers working on the face of clay rock with pneumatic drills

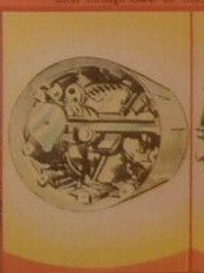


The Mersey Tunnel—or Queensway to give it its official title—is 2.13 miles in length, and linking Liverpool and Birkenhead, was built at a cost of £8,000,000. At its deepest point, the section of the tunnel is 170 feet below high water mark, and four lines of traffic can travel abreast in the main portion which has an internal diameter of 44 feet. On the right is a cutaway view of one of the six great ventilating stations that provide it with pure air.

The new Lincoln tunnel, 11 miles in length, that burrows under the Hudson River to link New York City with Weehawken in New Jersey. The sectional view shows an underwater tunnel in process of construction. 1. Hydraulic jacks pushing forward cutting shield. 2. Erectors are fits tunnel-shell segments into place. 3. Pneumatic guns force rams against segments to seal joints. 4. Emergency locks. 5. Workers enter and leave through an air lock. 6. Engineers enter through lower air locks.







London's underground railways are controlled by the London Passenger Transport Board. They comprise the world's largest network of tunnelling and railway lines—many miles from the centre—and one special to the building activities

The rotary excavator used for the construction of the railway on the Piccadilly Tube of the Underground is the best one seen the hydraulic rams at the back of the excavator

A fine work, and one that is second only to that of the Panama Canal, this is Gunnersbury (1 mile 1,760 yards) on the Metropolitan Railway, which has a maximum depth of 70 feet. The portals are noteworthy, their details are

Week ending March 26, 1938. Vol. 2. No. 45.

From time to time scientists report strange objects that suddenly appear in the sky—

ARE THEY VISITORS *from* MARS?

What do the Martians look like? Have they huge, domed foreheads and massive intellects or are they robot-like creatures with little brain? No one yet knows, although the mystery is not impossible of solution.

MARS is just drawing away from the earth after one of its nearest-ever conjunctions. Distance between the two planets is increasing at the rate of millions of miles a week—which, astronomically, is pretty slow.

While it was a big red spot in the sky, thousands of people were asking themselves if man would ever be able to send an expedition across space to make a landing on the planet.

Some of them shrugged their shoulders and dismissed the idea as impossible. Men once did that when they considered flying. Others, longer sighted, saw the chances and visualized, one day, a machine that would bridge the awful gap of forty-eight million miles of empty space.

Very few of these thousands pondered the idea that beings from Mars or any other planet had ever been here to this earth.

Yet it isn't such an absurd theory. If there ever was a civilization on Mars, if there still is, the facts go to prove that it must be an older civilization than ours, that the problems we now face must have been solved there many centuries ago.

And several scientists think that something, at various periods in history, has visited this planet from somewhere in outer space.

Charles Fort was one of them. He was an American scientist who died a few months ago. He was noted for his open mind and his impartial investigation of unorthodox information.

Many other scientists and astronomers have also investigated the possibilities, but few of them talk about their work except to intimate friends. The fear of ridicule is too strong.

Facts unearthed by Fort and the others are many. The majority of them are too well supported by independent, reliable witnesses to be lightly dismissed.

The early ones take us back to the days before aeroplanes, back to the '90's of the last century.

Anything that flew in those days was bound to excite comment. But the only machines man made to fly were balloons—and a spherical balloon isn't easy to mistake for anything else. Yet power-driven machines were seen in the skies.

There was a machine, wedge shaped, putting out a tail of flame, making a roaring noise, that was seen by most of the inhabitants of Delaware, U.S.A., in 1880. Thousands of witnesses support this statement. It was not a meteor. It disappeared over the horizon and wasn't seen again.

Later, three times a machine rather like a modern airship, but smaller (unless it was flying very high) was seen over various parts of Britain. It was streamlined down to a cigar shape and flew without noise. Again there are reliable witnesses, not in ones and twos, but in dozens.

And there is one instance, in Wales in 1900, of a man seeing one of these machines land. According to him there occupants were small and shaped like monkeys. But he was alone and had nobody to support his claims.

The great point to bear in mind is that in those days there was nothing built by men that could possibly come under any of these descriptions.

Again, early in this century, a fleet of winged things was seen very high up, crossing the sun, in Switzerland. They were seen through telescopes and from general descriptions must have been fairly similar to a modern monoplane. But there weren't any monoplanes in the world at that date.

Several strange sights that don't come under the sea serpent category have been seen in the sea. Most of them have been wheel shaped, with the spokes of the wheels about two hundred feet long, with a large hub.

Records of these wheels stretch from the present day back to 1750. There are records of them earlier than that, but these early records cannot be trusted.

Most of them have been seen as a wheel shaped light shining up to the surface of the sea from below, as if the entire machine were alight. But several records state that the wheels have been seen diving into the water.

Now a corroborative fact comes forward.

Many astronomers and physicists have stated that if a machine was constructed to travel through space, and it used radiation as its propulsive power, the best form for it would be a wheel.

If the machine was driven by rocket power one of the best forms would be a wedge. And the records of wheels and wedges are legion.

One wedge was found in Arizona. It was made of some form of stone and it had inscriptions on it. Nobody could make anything of the inscriptions. Charles Fort said it came from outer space and bore a message. It is still preserved in one of the big Arizona scientific museums.

Two big queries come into everyone's mind from these facts. One is this. If beings from other worlds have been here why haven't they communicated with us, earth's ruling species?

The other is that if strange machines have been seen in the past why aren't they seen now?

The first query is the most important. Its answer comes into the realm of philosophy. Its answer is this. Airmen flying over Africa no longer bother to land for the mere purpose of investigating the habits of the natives. Everybody knows them. It would be a waste of time to see and explore again.

Now suppose these travellers from space look upon us as we look upon jungle savages or animals. After all, there's no reason why they shouldn't. If they've solved the secrets of space travel and all it entails we can't be a very interesting civilization to them. If that is the case, why should they bother?

They've probably made all the investigations they want, anyway, either in the past or today, unobserved. It would still be dangerous for something strange to descend upon the average community. It would probably be attacked and killed.

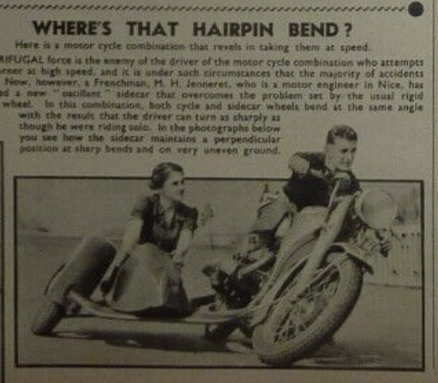
Fort says that they probably have something far more important on hand, that earth may contain some substance they require, and don't possess on their own planet, that their journeys here are to obtain that substance with as little unnecessary delay as possible.

So there it is. Things, beings, machines, may have visited the earth. There is just as much reason for saying they have as for saying they haven't.

WHERE'S THAT HAIRPIN BEND?

Here is a motor cycle combination that revels in taking them at speed.

CENTRIFUGAL force is the enemy of the driver of the motor cycle combination who attempts to corner at high speed, and it is under such circumstances that the majority of accidents occur. Now, however, a Frenchman, M. H. Janneret, who is a motor engineer in Nice, has produced a new "oscillant" sidecar that overcomes the problem set by the usual rigid sidecar wheel. In this combination, both cycle and sidecar wheels bend at the same angle with the result that the driver can turn as sharply as though he were riding solo. In the photographs below you see how the sidecar maintains a perpendicular position at sharp bends and on very uneven ground.



SCIENCE MARCHES ON

- CRICKET ENEMY
- ACCIDENT HELPS SCIENCE
- NEW LEAGUE ACTIVITIES

BURN CURER

A LABOURER in a north country chemical factory slipped and flung his bare arm across a pipe to save himself.

He slipped farther because the pipe was boiling hot. In falling his burned arm plunged up to the shoulder in a trough full of a chemical solvent used by his firm—a substance called amyl acetate, and sometimes called "pear drops." (from its smell) or "banana oil."

In spite of his severe burns the man felt little or no pain from his arm. He stood the subsequent dressing in the first-aid room unflinchingly. And that fact set the doctor, and other doctors, thinking.

The final result has been recently reported in the *British Medical Journal*—a new and speedily effective treatment for burns, which, with their attendant shock and infection, are the doctors' bugbear.

The fluid dressing used contains amyl acetate because it is so powerful an analgesic, or painkiller, for burnt tissue. But because it is not antiseptic, a germicide belonging to the methyl tertiary butyl phenols is added to the solution.

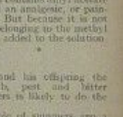
* * *

FARMERS' PAL

Doddy Londesley and his offspring the leatherjacket grub, pest and bitter enemy of all greenkeepers is likely to do the farmer a good turn.

In this way. A couple of summers ago a greenkeeper to a small country cricket club tried out potassium permanganate as an aid to wiping out the grubs which were ruining his wickets and eating up the turf roots from his pitches. (You will remember Oval and Lord's were seriously worried a season or two ago about deadly-longlegs' depredations. They threatened to stop a Test Match.)

And this greenkeeper noticed that turf so treated grew more thickly and stronger. He tried out permanganate mixed with fertilizers on the lettuce and radishes in his kitchen garden and got bumper crops.



Fertilizer manufacturers are now adding traces of permanganate to their product and getting glowing reports from satisfied farmers.

Theory is that permanganate being a powerful teaching agent breaks down organic nitrogen into nitrates, easily assimilable plant food, in the soil. The manganese, released in small amounts is also useful, as many soils are deficient in this valuable substance.

* * *

DOG EAT DOG

One of the dreams of the medical researcher is the discovery of an organism which will eat germs.

During the war a British doctor named F. W. Twort was making vaccines. Examining one of his culture tubes one day the microscope showed him only dead and dying bacteria.

Some mysterious substance or organism had come through his filters had got into the colonies and killed them. Bacteriophage—"bacteria eater"—he called this substance, phage, for short.

Ever since that day laboratories all over the world have been trying to isolate "phages," to find out what they are, how they can be made, how they behave. And now, due to the work of Rockefeller Institute's J. H. Northrop, and Dr. Krueger of the University of California, the secret is out.

Those "phages" are non-living. They are protein molecules of that complex substance which forms the major portion of the solid matter in our tissues. And such a molecule will grow and multiply like a living thing. But only in the presence of a parent substance found in bacterial cells.

So—germs can carry within themselves the seed of their own destruction.

* * *

LEAGUE PROGRESS

The latest reports from both the Chemistry and the Astronomical Sections of Modern Wonder League of Science show that they are going ahead by leaps and bounds. In fact, Mr. Ralph Strange, our Director of Activities, is living strenuous days at present.

Applications for membership are like the little oysters in *Alice in Wonderland*, for "thick and fast they came at last; and more and more, and more!"

* * *

NEW ACTIVITIES

And now here is an important item of news that will appeal to all members of the League of Science. We intend to start an Air Section. This will be under the personal supervision of Meurice Winona's Special Air Correspondents, Mr. Selby Lewis, and Mr. M. R. Knight.

The latter will deal with all questions connected with model aeroplane construction and his expert advice and instruction will be of the greatest assistance to all those of you who are keen on this absorbing hobby.

* * *

JOIN NOW

If you are among the few who have not yet joined the League, do so without any more delay. It offers the chance to all scientifically-minded boys to study the subject that interests them most and to apply their knowledge to the best advantage. Members are forming their Science Clubs in all parts of the country and are enthusiastic about the help they derive.

And it is a simple matter to become a member of the league.

Cut out your newspaper a regular order for Modern Wonder, then simply send a note to the Editor applying for membership. State your full name, age and address, and tell him the science in which you are most interested. Write clearly in block capitals and enclose a 1½d. stamp.

Address your letters to The Editor, Modern Wonder, Martlett House, 31, Bow Street, London, W.C.2, and write in the top left-hand corner of your envelope, "League." You will then receive your membership card.

MODERN architecture is featured prominently in the construction of this bridge in the grounds of the next World's Fair of 1939 which will be held at Flushing on New York's Long Island. It leads to the Administration Building.

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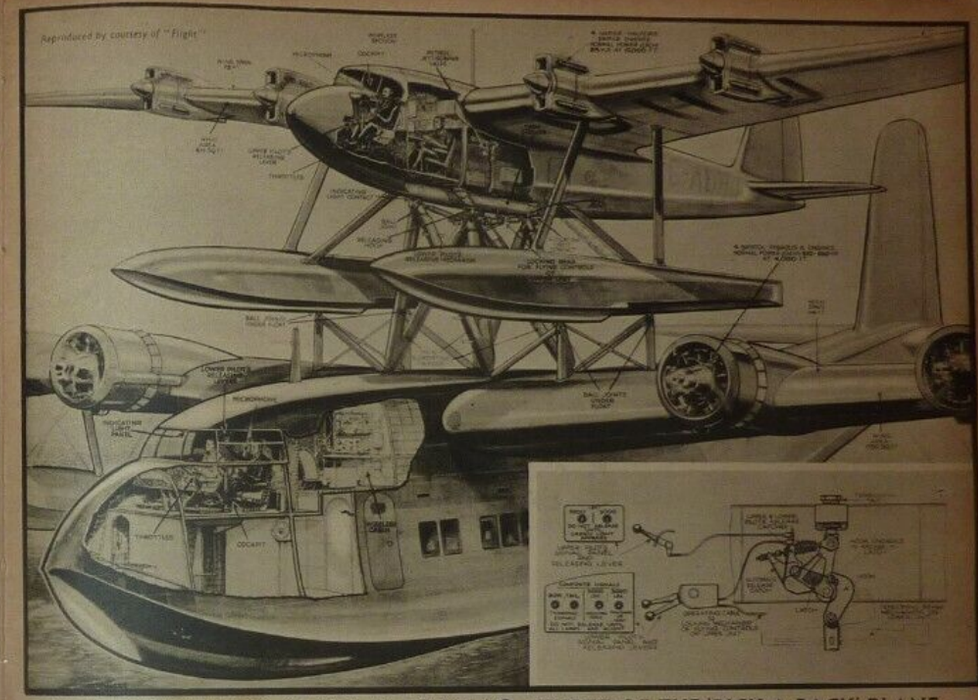

SECRET OF THE 'PICK-A-BACK' PLANE

NO flying experiment has attracted such world-wide attention or has such great potentialities as the Mayo Composite Aircraft.

For months past now, pictures of the two aircraft which form the complete machine and articles about it have appeared in the newspapers. None of them has told the whole story.

It can be divided into three chapters: The Man, The Machine, The Future.

The Man is Major Robert Hobart Mayo, now technical general manager of Imperial Airways, inventor of the composite aircraft. Tall, lean and broad-shouldered, he conceals behind a quiet, diffident manner one of the most brilliant aeronautical engineering brains in the country.

He is forty-seven and looks younger.

Born in Cambridge, he went down from the university with double firsts in engineering and mathematics. That was in 1913. His first job was on the staff of the Royal Aircraft Factory at Farnborough. Next year, when only twenty-four he was appointed head of the experimental department.

His life has been spent in aviation. In it he has found thrills and adventure. In the composite machine he has justification for being thrilled, for its development may very soon revolutionize high-speed long-range air transport.

Now for **The Machine**. Six years ago Major Mayo made a trip to America and the West Indies to survey the possibilities of the proposed Atlantic air services.

Major Mayo conceived the idea of the composite machine on that trip.

To overcome the difficulty of obtaining speed and range as well as ability to carry a payload he envisaged a machine capable of fast flight over at least three thousand miles, and loaded with a given quantity of freight.

This machine would be unable to get into the air by itself. To supply the deficiency of power for the take-off, the transport machine would be mounted on the back of a large, lightly-loaded craft.

For the prototype, or first, machine, marine aircraft were chosen. Major Mayo worked with Mr. George Gouge, chief designer and manager of Short Brothers at Rochester, builders of the Empire flying boats. It was decided that one of the Empire flying boats should be used as the parter or lifting machine.

From the sectional drawing above the sectional arrangement of the composite aircraft will be seen. The upper component, *Mercury*, rests on supports on the lower component, *Maia*, on a strong central keel in its fuselage, and is steadied laterally by smaller supports under its floats. Switches are incorporated at upper ends of a cruciform trestle and show the form of the mechanism.

The release-hook mechanism is placed centrally and includes three separate hooks, as shown in the inset.

First the lower pilot releases his hook, then the upper pilot releases his, and finally the spring-loaded automatic hook disengages when the excess pull of the upper component has reached a certain predetermined value.

The Future. Major Mayo has given seven-league boots to the transport aeroplane. The first machine having proved the composite principle, the possibilities of its development are immense. His invention will make possible the opening-up of new world routes by Britain.

The composite machine, able to fly thousands of miles without having to land for petrol, can ignore the complications of landing in foreign countries, and keep from the British possessions to another

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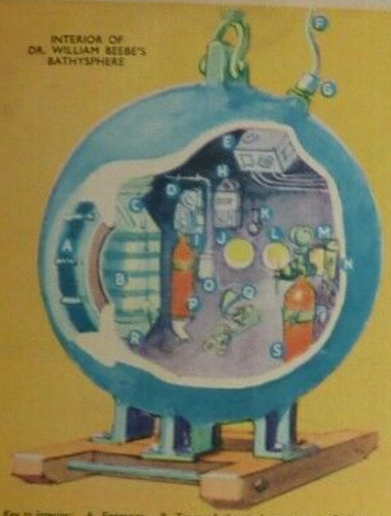
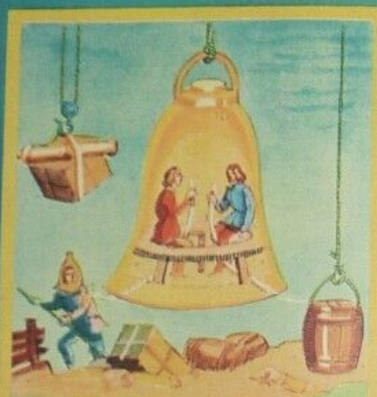
MONSTERS *of the* DEEP

Half a mile down with Dr. William Beebe in the Bathysphere

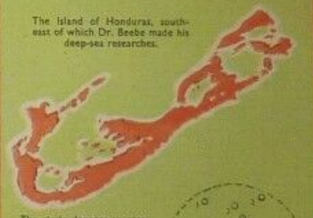
INTERIOR OF DR. WILLIAM BEEBE'S BATHYSPHERE



Key to Interior: A, Entrance. B, Trays of chemical apparatus. C, Blower. D, Oxygen tank valve. E, Switchbox for blower and searchlight. F, containing Electric power and telephone wire cable. G, Stuffing box. H, Thermometer-humidity recorder. I, Mouth of oxygen tank. J, Observation window. K, Barometer. L, Observation window. M, Searchlight window. N, Searchlight. O, Telephone tool and battery box. P, Oxygen tanks. Q, Telephone. R, Pan of chemical apparatus. S, Oxygen tank valve.



This eighteenth-century Diving Bell, built by Halley, the astronomer and physicist, was used successfully for descents up to nine or ten fathoms. Fresh air was sent from the surface by alternating barrels, each of which connected with the bell by means of a leather pipe, and another leather tube brought air to the diver who wore a helmet of skin. It was possible for those in the bell to remain below surface for an hour and a half.



The Island of Honduras, south-east of which Dr. Beebe made his deep-sea researches.

The circle denotes an area over which 1,500 deep-sea nets had been drawn. The numerals show the sites of Dr. Beebe's four descents.
1. 1,426-ft. dive in 1930.
2. 2,200-ft. dive in 1932.
3. 2,510-ft. dive on Aug. 11, 1934.
4. 3,028-ft. dive on Aug. 15, 1934.

BY descending half a mile under the sea in his bathysphere, Dr. William Beebe, the famous oceanographic naturalist, added greatly to the small amount of existing knowledge of the strange, nightmare-like creatures that exist far below the surface, many of them in stygian darkness, never venturing from their strange home in the ocean depths.

On the left you will see some of the amazing creatures seen through the heavy quartz windows of the bathysphere. 1. A tailless eel making a raid on a school of Scarlet Arrow worms. 2. This thin, delicate crustacean is the Needle Head. 3. Sharp, pointed spikes provide this strange fellow with a natural protection from attack. 4. This 6-ft. giant of the depths, with its luminous sides gleaming in the darkness like a lighted liner and trailing its own "traffic lights," was named the "Untouchable Bathysphere fish."

5, 6 and 7. A drama of the deep. The Black Swallower (6) has just attacked a Unicorn fish, three times its size, and has succeeded in getting its head in its mouth. The sequel is seen in 5, the Black Swallower—now looking more like a black pudding!—swims off to digest his enormous meal. 8, The Great Gulper Eel, 55 inches long, makes a light meal off a Ginot Lanternfish. 9. This fellow with the enormous mouth is a Gulper Eel.

10, The Viper fish, one of the fiercest creatures to be found. 11, This Telescope-eyed fish provides a touch of comedy. The Five-lined Constellation fish (12) looks as solemn as the Black Whalelet. (13), looks bad-tempered. 14. These brightly coloured creatures, known as Abyssal Rainbow "Gars," swim in a stiff, precise manner as though they were soldiers.

15, A luminous fish being attacked by Scarlet Shrimps (16) which discharge a cloud of luminous fluid to blind their adversary. 17. Only one inch long, these young Sabre-toothed Viper fish are fierce fighters. 18. Another of the Untouchable Bathysphere fish found 2,000 feet below sea level.

Continuing ISLAND OF TERROR

changed suddenly to a wild cheer as it was seen that the rising plane had missed disaster by a fraction.

"She's away!"

They watched the plane climbing in a wide circle. She altered her course suddenly, in a graceful curve, and her nose swung eastward as she disappeared into the blue like a homing pigeon.

"Well, that's that!" Sammy Dring said unagreeably to his three companions. "All we have to do now is tighten our belts and wait, boys."

But Sammy knew, as he watched a speck in the sky that was now the *British Queen*, that he would never be content to sit still and wait for something to happen. That, quite definitely, was not Sammy Dring's nature, and for this reason he was chosen by Destiny to remain on the island. Sammy Dring simply could not sit still and do nothing, and do such trivial traits in the characters of men do crises of world-wide importance arise.

An atmosphere of gloom overshadowed the great airport at Foynes, on the west coast of Ireland. It could be detected among the groups of mechanics who were off duty, and among others lounging about the outbuildings of the great aerodrome facing the Atlantic Ocean. Pilots met and spoke together in subdued voices. Everybody there had long since ceased to look for automatic signals from the top of the giant steel pylon where the light-house and watch-tower were perched.

Although they had not yet openly admitted it among themselves, every man appointed to the airport knew that there was now no hope of news—good or bad. Far out over the rolling wastes of the Atlantic the *British Queen* had met with disaster in the most terrible storm in living memory.

And the mail plane *British Queen* was the pride of Foynes.

The *Boston Clipper*, magnificent American machine, must have suffered the same fate, for she was now many hours overdue. Not even the skill of those veteran pilots, Whitaker and Verrant, could save the two finest machines of their class to the world from disaster under such fearful conditions over the Atlantic.

To the opinion of the commanding officer at Foynes: "They couldn't have lasted in the air for much more than an hour." It was an opinion shared by all whose daily work took them into the kingdom of the air.

Nobody troubled even to look up at the rapid flashes of light-signals from the top of the steel pylon, but a chance observer drew the commander's attention to them.

"Something's being signalled in, sir," he said, "and we've had no report. I wonder who . . .!" The speaker, who was also the landing officer, broke off to bawl orders at a group of men near the sheds.

"Hi! You there! Prepare Number Two landing ground."

An alarm bell rang loudly, scattering the group of men to left and right.

The commander took down a pair of powerful binoculars from a rack above his desk, and walked out on to a wide verandah beyond the office to focus them upon a speck humming in the distant sky. For a full minute he watched the approaching plane, and then handed his glasses to the landing officer waiting impatiently for news.

"I must be getting old," the commander said. "Can't trust my own eyes lately. Tell me what you see up there."

It became the commander's turn to shuffle about impatiently on the verandah while the other man stared long and earnestly at the growing speck against the sky.

"It's a big machine—a plane of the . . . I must tell you she reminds me very much of the *British Queen*, sir! Impossible, of course, after all this time, but . . . I can't make it out!"

"Keep her in sight!" rapped out the commander excitedly. "Don't put the glasses down until you're sure, man!"

There followed a tense silence on the verandah. In all parts of the great aerodrome men were staring upward with painful intensity. What was this flying in from nowhere over the Atlantic?

The officer lowered the binoculars at last, offered them to the commander with hands that shook. "Look for yourself, sir," he said simply.

"I shall do nothing of the kind," the commander snapped. "Your eyes are twenty years younger than mine. Now what do you make of her?"

"It—it's the *British Queen*, sir. I—I know it's impossible. But there she is! Look for yourself!"

A telephone rang shrilly on the commander's desk, and he dashed inside the office to lift the receiver.

It was a voice vibrating with pride, even triumph, that spoke emotionally from the look-out tower. "The *British Queen*, sir. I can't get a signal out of her, but she's preparing to land."

Before the commander could reach the verandah, the mail plane had been sighted and recognised in all parts of the airport. The *British Queen*! Hooray!"

Despite his sixty years, the commander set a fast pace over the grass toward Number Two landing ground. As the mail plane made a perfect landing and drew to a halt she was surrounded by a wildly cheering mob of men. The crowd parted as stern commands rang out to allow the passage of officers to the door of the control-cabin. When Captain Whitaker appeared with the chief pilot of the *Boston Clipper* behind him, shouts of amazement went up on all sides.

"It's Verrant! Verrant! Where's the *Boston Clipper*?"

To the surprise of the crowd the two pilots refused to step down from the door of the cabin. When the bewildered commander of Foynes reached Whitaker the latter bent down and whispered urgently.

"I have confidential information of utmost importance to report, sir. Will you come into the main cabin?"

The commander was assisted to the platform beside Whitaker, leaving the crowd outside in a fever of speculation. A few minutes later a door of the main cabin opened, a gangway was placed in position, and four exhausted men followed the commander out of the *British Queen*.

"Jimmy Farrol! Charley Grant! What's been happening?"

But the four men returned from the dead walked on behind the commander without a word. The waiting crowd were electrified with excitement when armed sentries were posted outside the office. Had they been permitted to see and hear what was taking place inside the commander's room at that moment, the crowd might have been thrilled to the core.

The commander hesitated as he faced the four men, with a trembling hand poised over the telephone.

"You're quite sure there is no mistake?" he quavered.

"The sight of the *British Queen* outside your office window should be sufficient to eliminate any chance of a mistake, sir," said Arnold Whitaker stiffly.

When the commander lifted the receiver he spoke slowly and distinctly. "Stop all out-going telephone calls and all mails immediately," he said, "and send the press officer here right away. I want a strictly private conversation with the Air Ministry as quickly as possible. When you have the Ministry give the codeword for State. Don't delay for a single moment, and keep on at them in London until the Minister for Air himself is at the other end of the line. I shall not leave my office until you call me. Understand? Good!"

The commander of Foynes looked a few years older, his face strained with anxiety, when he glanced up at the four airmen gathered in his office. "We can't keep such news as this to ourselves much longer," he said. "I don't mean that the information isn't safe here, but a slip of any nation may give the news to the world at any moment. I expect you are all very tired and hungry, and I've ordered the best meal we have in the place to be laid out for you.

"Now you must all remain here with me until we get a reply from London. You'll find that a meal is already waiting for you in the other room, and——"

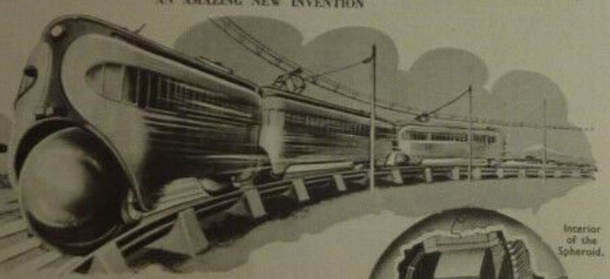
But the hungry men did not wait to hear the rest. All had caught an appetising odour wafting from the other room, and they left the commander seated at his desk. The call from London came soon after the remains of the meal were cleared from the table. When the commander came in he spoke impressively.

"Captain Whitaker and Captain Verrant! You will please enter a plane I have waiting outside for you now. The Minister for Air and the American Ambassador are awaiting your arrival in London. An escort of police will take you straight from Croydon to Whitehall. James Farrol and Charles Grant will remain at Foynes, and sleep aboard the *British Queen*. These are joint orders from the Air Ministry and from the American Embassy in London, gentlemen!"

(To be continued next week)

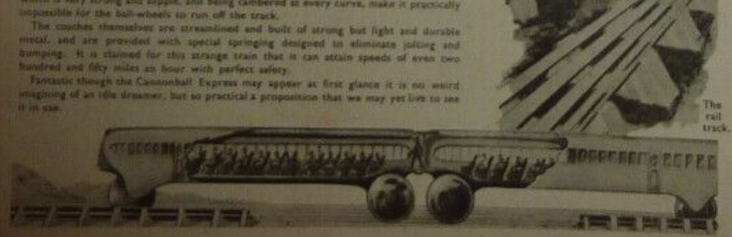
THE CANNONBALL EXPRESS

AN AMAZING NEW INVENTION



Interior of the Spheroid.

The rail track.



TRAIN TO TRAVEL AT 250 M.P.H.

OUR cover illustration this week gives a vivid impression of an entirely new form of railway locomotive as represented by the Cannonball Express. The invention of a young American engineer, this train runs, not on wheels, but on enormous ball-bearings, one of which is situated at each end of every coach. The gigantic spheroids contain electric magnets, and the power is conveyed to them through a hollow axle, and overhead electric wires, somewhat similar to those in operation on trolley-bus routes, supplying the requisite current which is controlled from the driving cab placed in the front of the forward coach.

These "cannonballs," as they have been nicknamed, fit securely on a grooved track which is very strong and supple, and being cambered at every curve, make it practically impossible for the ball-wheels to run off the track.

The coaches themselves are streamlined and built of strong but light and durable metal, and are provided with special springing designed to eliminate jolting and bumping. It is claimed for this strange train that it can attain speeds of even two hundred and fifty miles an hour with perfect safety.

Fantastic though the Cannonball Express may appear at first glance it is no weird imagining of an idle dreamer, but so practical a proposition that we may yet live to see it in use.

Voyage into Space

• *Illustrated by Chester*

AN ENTHRALLING SAMPSON PARR STORY OF STRATOSPHERE ADVENTURES

by

G. Hamilton TEED

Through the aperture the giant globe streaked out into space.

My friend, Professor Sampson Parr, the eminent physicist, was a scientist of indefatigable purpose. All was grist that came to the mill of his probing mind, and I, Peter Bartlett, a humble technologist, was proud to play a recording Boswell to his scientific Johnson.

While his chief interest lay in the profound realm of cosmic phenomena and a patient approach to the problem of splitting the atom (which, he maintained, would open the way to an understanding of the fourth dimension) he was no less absorbed in the study of plant and animal behaviour.

I had not been down to his place in Devon for some weeks—not, indeed, since the amazing "battle" he had waged with his atom-splitting "gun" against the strange visitants from outer space. I was very busy with the erection of a new rayon plant near Slough when I received a telegram from Tony, Parr's young nephew, saying his uncle was anxious for me to run down for the weekend if I could manage it.

It was just past nine o'clock when I turned in at the big, wrought-iron gates where the drive, nearly a mile long, led to the massive Elizabethan mansion which was Parr's home.

As I entered the wonderful laboratory, Parr was seated at a table tapping away at an ordinary telegraph key. One section of a huge metal globe on the bench before him was open and, through this, I could see Tony crouched before a battery of lights. As Parr tapped, the lights changed in quick succession and, at each change, Tony would call out some result which would cause Parr to nod his head.

Neither paid me the slightest attention until Parr finished his tapping and reached for a notebook. Then he merely said:

"I believe I've struck something rather interesting and, like so many discoveries, I hit on it by sheer accident."

"What is it, Parr?"

"Gravitation," he said laconically, "or, rather, the conquest of gravitation—the hope of every scientist since Newton discovered the Law.

I gasped and looked at him incredulously. But he went on imperturbably.

"You know, Peter, I have always held that gravitation is utterly different from other attractive forces that we know, such as electrical and magnetic. Moreover, gravitation, *in itself*, is a very feeble force. We think of it as tremendous because we only know it as belonging to an object of vast bulk such as our earth. If we deal with it in relation to a comparatively small object we find it most difficult to measure and that is simply because it is a feeble force."

"Yes, I've heard you say that before, Parr."

"It is essential to the student of astronomy that he should know something of this Law because it is the foundation of astronomy. Einstein has, of course, rather modified Newton's Law by his Theory of Relativity but in essentials it is still the keystone."

"Well," went on Parr, "I was rather startled some time ago when, during the course of some preliminary experiments aimed towards a fresh approach to splitting the atom, I saw the apparatus upon which I was working, leave the floor and rise with great speed until it crashed against the roof of the laboratory. It struck so forcibly, in fact, that the mechanism was smashed irretrievably and, although I was able to guess the reason, it was some time before I could discover just why it had happened. Luckily, my notes were sufficient to help me, so, by following the same process, I arrived at the same effect."

And you mean to say you can neutralise the effect of gravitation?"

"To some extent at least. That is why Tony and I built our sphere and fitted it with a development of the apparatus which was originally intended to measure atomic structure."

"All aboard for the stratosphere!" Tony laughed.

"That's a little premature," Parr retorted. "I am not quite mad enough to trust myself or anyone else to such a frail craft for a journey into the stratosphere. Piccard was a brave man to travel as he did, but he only tapped the stratosphere. His journey was the equivalent of a diver descending two or three hundred feet into the ocean with several miles of unplumbed deeps beneath him. This sphere will be a little more than a bullet for I shall test the controls before the final release."

I obeyed and laid a hand on the smooth side of the sphere. Suddenly I felt a movement against my palm and thrilled again as I saw the sphere moving upwards.

I could scarcely believe yet that the blue flashes that were cracking above Parr's head from a huge, glass-enclosed transmitter were controlling the movement of that unattached sphere; but, when they ceased and the sphere thudded gently back to the floor, I knew that it was so.

"It's off this time, Tony," Parr snapped crisply. "Check."

"O.K., sir."

I stood back and watched the sphere rise again, slowly as before. It floated more like a solid soap-bubble than anything else I can think of and, when it was poised, half in, half out of the opening in the roof, it hung motionless. Parr had again exercised control.

Then an incredible thing happened. I was standing gazing up at the sphere when it vanished with such amazing speed my eye could not follow. One moment it was there, the next it simply wasn't. But I knew it had gone *upwards* and I knew that, within a matter of moments, it must already be through the troposphere and shooting on through the stratosphere with the speed of one of "Big Bertha's" shells.

Parr was intensely concentrated on his work. The blue sparks were crashing above his head. Tony was bent over his receiver taking the signals that were thrown back from the Kennelly-Heaviside layer sixty miles above.

What sort of a world was that tiny sphere plunging through? What had it seen already? What temperatures were the instruments showing? What pressure?

Nothing in that starlit sky could tell me. It was Tony's voice, sharp with excitement, that brought my gaze down.

"Nothing is coming back," he shouted to Parr.

"Take your stand by the sphere, Peter," he ordered me. "It won't start yelled Parr. "Are you on the same wavelength?"

"Absolutely."

I walked across to where Tony sat. He was clenching the edge of the table, his eyes closed while he tried to pick up the signals through a pair of earphones. Then his mouth opened and he called again to Parr.

"Not a sound, sir."

Parr said nothing. I did not know then, but he told me later, that he was trying to bring the sphere back to earth. But I knew when he stopped the key and leant back that something had gone wrong—very wrong.

"Well, that's that," he said laconically.

"What do you mean?" I asked him.

He laughed. He was too philosophical to show bitterness.

"We've lost it, Peter. I don't know whether my wireless control was too weak to hold it after it reached a certain height or whether the apparatus failed. If I couldn't hold it, then it has shot right up above the Kennelly-Heaviside layer and by now will be almost outside the five hundred mile limit of earth's atmosphere."

"Shooting into space?"

"Exactly; and to go on shooting as long as that molecular energy continues—which may be through inertia for all we can tell yet."

"And if it should be a failure of the apparatus?"

"In that case, it is travelling back towards the earth at ever-increasing speed. If it is, it must land somewhere and we may learn where."

But we never did learn what became of the sphere, because there was no news to report the crashing to earth of a strange object in the untracked depths of the jungles of the Upper Amazon.

I returned to town on the Monday and did not see Parr again for six months. Then I received a letter from him.

"My dear Peter," it read, "Can you run down before the end of the week? I am contemplating what may prove to be a signally eventful journey, and I'd like to have a talk with you before I leave."

I couldn't get the letter out of my mind. Sampson Parr was not the one to refer lightly to any journey being signally eventful" unless it was of a serious nature. I telegraphed to say I would be down the following day. It was more like early summer than spring, for the sky was almost a Mediterranean blue, and the sun was gloriously warm.

I was surprised to see as I goaled my car up the drive to the house, that aside my previous visit a new erection had appeared. It stood to the right of the underground laboratory and it wouldn't be a bad description if I said it looked like a gas container. At any rate, it was about as high as those one sees in London and, roughly, about the same diameter.

I soon discovered, however, that this impression was gained by the fact of the circular wall which was of galvanised iron, and then, as I slid out of the car and walked towards the structure, I saw a sort of covered tunnel near the base which led downwards. I needed no great amount of intelligence to deduce that this tunnel connected with the underground laboratory. While I stood looking at the ugly affair and asking myself what the deuce Parr could have built it for, I saw Tony appear, grinning.

"Well, old horse, how do you like our new hangar?"

"Hangar!" I echoed. "It looks more like a bad hangover to me. What's it for, Tony?"

"Wait until you see the guv'nor. He's waiting for you down in the lab."

I followed Tony down the steps to the entrance I had always known, and found Parr in overalls, working on what I was informed, was a thereal suit.

"Hello, old man," he greeted me absently. "glad you were able to come. Get some tea, Tony."

Tony took himself off and Parr started towards the far end of the laboratory.

"Come along, Peter; I want to show you something."

I followed him. We reached the end of the main laboratory and passed into the dynamo room. From here we went up some steps that were new to me and which I knew must lead through the tunnel affair I had seen from above ground. Then, he opened a door and I gave a gasp at the sight which met my eyes. I knew now the meaning of the new structure.

Enclosed within it, but not occupying

(Please turn to page 10)

CANADIAN PACIFIC UNIFORM REGULATIONS

1, Captain and staff captain; 2, chief officer; 3, first officer; 4, second officer; 5, junior officers; 6, chief engineer; 7, assistant chief engineer; 8, second engineer; 9, third engineer; 10, fourth engineer; 11, junior engineer; 12, purser; 13, second purser; 14, senior surgeon; 15, junior surgeon; 16, assistant purser; 17, writer; 18, rail traffic representative; 19, chief steward; 20, second steward; 21, first electrician; 22, second electrician; 23, third electrician; 24, wireless operator; 25, senior plumber; 26, junior plumber; 27, boatswain; 28, boatswain's mate; 29, quartermaster; 30, carpenter; 31, carpenter's mate.

HOLIDAY CRUISE ON A MODERN LINER

ONE of the most remarkable changes in the holidays of the average Britisher of recent years is the great growth of foreign travel and the coming of the cruising holiday, available today for the man and woman of moderate means, who never before had a chance to see so much in a fortnight.

The glamour of the South, the beauties of Portugal, Spain (in happier days in that country), the Mediterranean, the Riviera, the glamour of Morocco and the beauties of the Atlantic Isles.

Or, if desired, the ocean holiday-maker can travel northward to see the scenic wonders of the Norwegian fjords, cruise in the calm Baltic, visit Helsinki in Finland, Oslo, Stockholm, Copenhagen, Zoppot, the Kiel Canal and Northern Germany.

The ship depicted in our illustration is one of the famous "Mont" ships of the Canadian Pacific Steamship Co., Ltd. (Canadian Pacific Railways), with whose kind co-operation and assistance the drawing was made. These ships are among the most popular of British cruising liners.

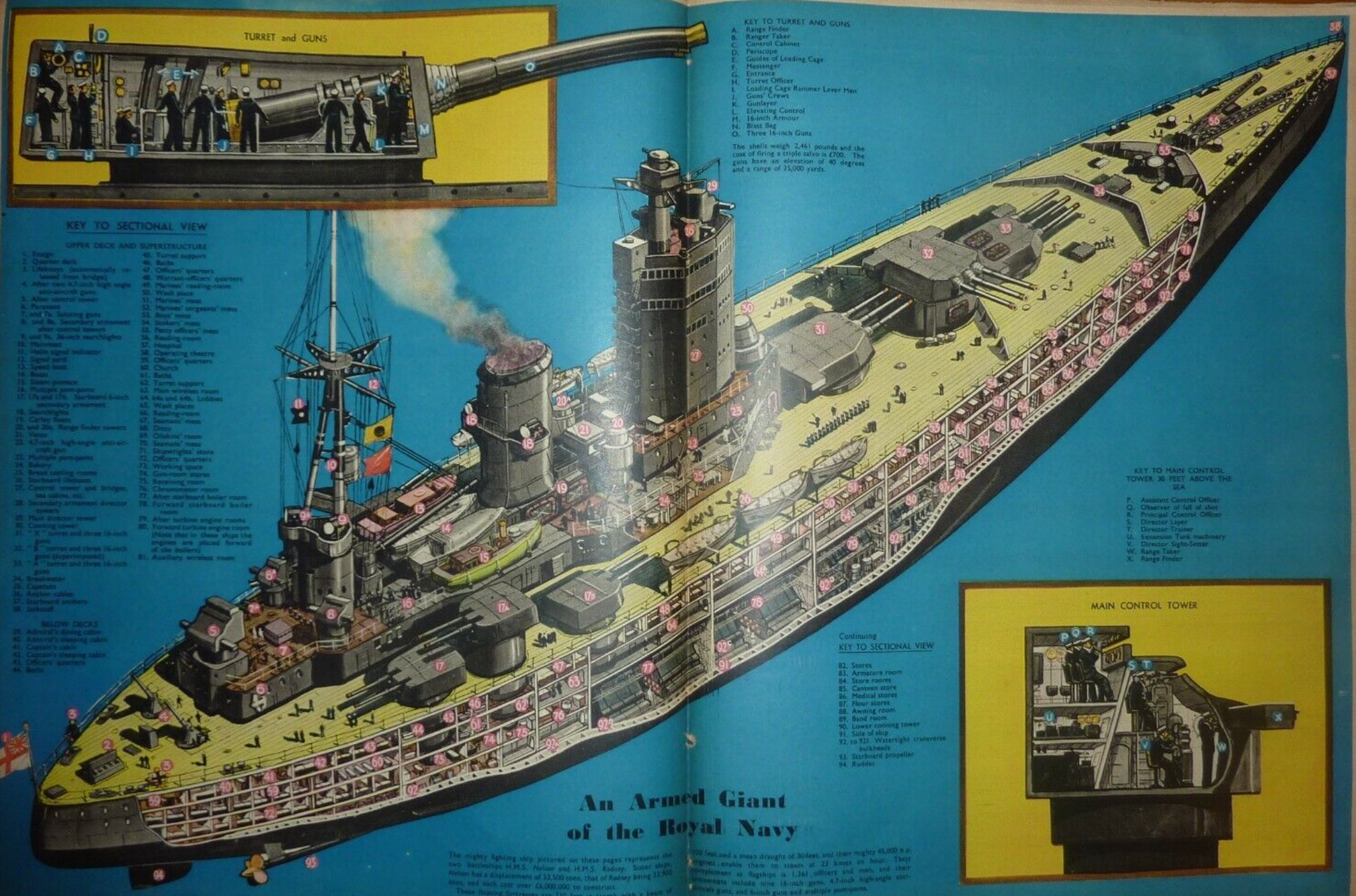
From the time that the passenger goes on board either at London (Tilbury), Southampton or Liverpool, he is looked after lavishly. He can have no set anything he desires, he has skilled stewards to look after him. Sports of all kinds are provided and games are organised by special sports officers and a skilled cruise director. There are race meetings, cricket matches, aquatic sports in the pool, and, of course, dancing every evening.

Thus the lucky cruiser can see all the wonders of strange lands in the greatest comfort in a 16,000-ton liner.

The flags shown on the [illegible] familiar to all cruisers as they are the code [illegible] of the flags of the International Code.

Various ships [illegible] liners, usually distinguishable by their [illegible] their promenade decks and [illegible] and [illegible] is [illegible] by the International [illegible] Mediterranean [illegible] American [illegible] during a [illegible] Atlantic [illegible].

Motor ships [illegible] of cases carry funnels, but [illegible] [illegible] [illegible]



An Armed Giant of the Royal Navy

The mighty fighting ship pictured on these pages represents the two battleships H.M.S. *Nelson* and H.M.S. *Rodney*. Sister ships, *Nelson* has a displacement of 33,500 tons, that of *Rodney* being 33,900 tons, and each cost over £6,000,000 to construct.

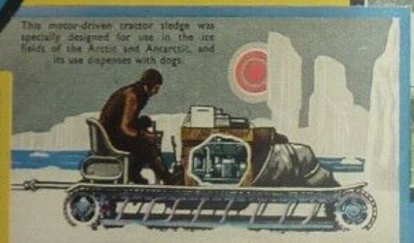
These floating fortresses are 710 feet in length with a beam of 106 feet and a mean draught of 30 feet, and their mighty 45,000 h.p. engines enable them to steam at 23 knots an hour. Their complements as flagships is 1,361 officers and men, and their armaments include nine 16-inch guns, 4.7-inch high-angle anti-aircraft guns, and 6-inch guns and multiple pom-poms.

SCIENCE AIDS THE EXPLORER

Miles above the earth the aeroplane climbs dizzily on its attack on the altitude record; into the uncharted vastness of the stratosphere soars the balloon with its gondola packed with scientific instruments. Far below the sea the bathysphere explores the wonders of the ocean bed, and in the frozen wastes of the poles, in the humid, fever-ridden jungles of the tropics and the arid deserts, scientists by their skill are making the work of the explorer more important.

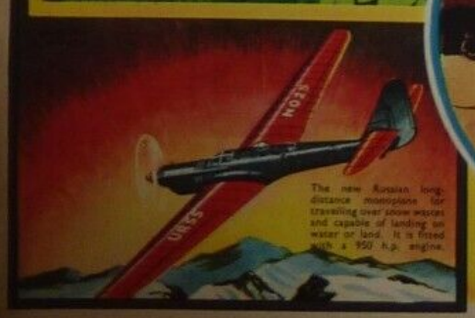
The R.A.F. machine used for altitude record-breaking: 1, special Bristol Pegasus engine; 2, cooling radiator; 3, blower; 4, petrol tanks; 5 and rear, pilot in special high altitude suit; 6, oxygen container; 7, official sealed

One of the wonderful new caravan trailers built for the explorer, Commander Attilio Gatti, for use in the African jungles. Costing about £3,700 it is fitted with special air-conditioning plant, electric refrigeration and includes a bathroom and kitchen.

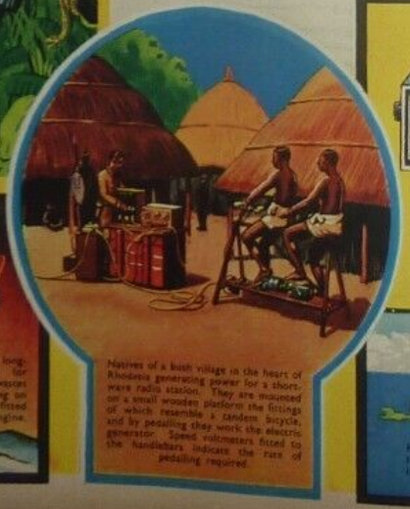


This motor-driven tractor sledge was specially designed for use in the ice fields of the Arctic and Antarctic, and its use dispenses with dogs.

A remarkable caterpillar tractor used for cinematography in the jungle. The camera is mounted on a periscope protruding from the circular conning tower in the front of the machine, and near the back is a powerful searchlight.



The new Russian long-distance monoplane for travelling over snow wastes and capable of landing on water or land. It is fitted with a 950 h.p. engine.



Natives of a bush village in the heart of Rhodesia generating power for a short-wave radio station. They are mounted on a small wooden platform the fittings of which resemble a tandem bicycle, and by pedalling they work the electric generator. Speed voltmeters fitted to the handlebars indicate the rate of pedalling required.

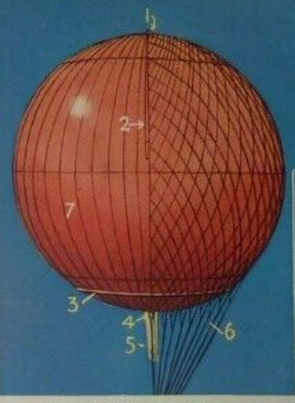
The illustration above shows the difference in focal length between an ordinary camera lens and one with a long telephoto lens placed in front of it. The telephoto lens, by magnifying the object, makes it appear nearer than it really is.

Here is a remarkable photograph of the sea off the Isle of Man taken with a telephoto lens and infra red plate that is not affected by fog or haze.

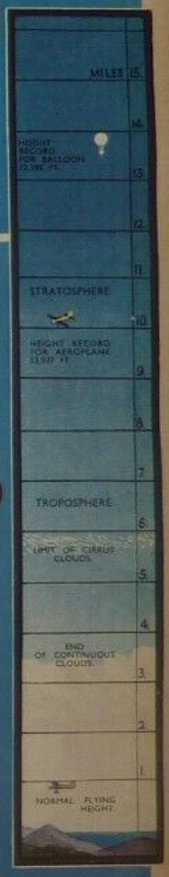
EXPLORING EVEREST FROM THE AIR

The machine in which an important survey flight was made over Mount Everest and back. Points shown on the machine are: 1, Bristol Pegasus engine; 2, engine-driven generator; 3, 14-gallon petrol tank; 4, oil tank; 5, 90-gallon petrol tank; 6, pilot; 7, electrically driven and heated camera; 8, observer; 9, instruments and control board; 10, observer's cockpit; 11, accumulator; 12, three oxygen bottles; 13, spare oxygen bottle.

Method of heating clothing worn on the Everest flight.
1, oxygen pipe; 2, heating connection; 3, telephone connection; 4, breathing mask; 5, heating elements; 6, electric cables; 7, sheepskin boots.

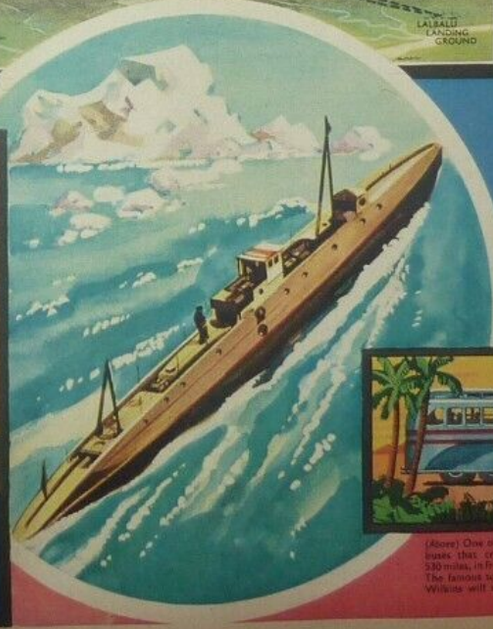


Details of envelope of stratosphere balloon: 1, valve for releasing gas; 2, ripping panel for use when landing; 3, rain gutter; 4, ripping line; 5, neck of envelope; 6, net; 7, envelope.



Details of the rig of a stratosphere balloon: 1, shrouds; 2, spectrograph basket; 3, parachute; 4, trap porthole; 5, vision porthole; 6, equipment parachute; 7, manhole; 8, lead-dust ballast; 9, gondola; 10, drag rope; 11, battery boxes; 12, inflated bumper; 13, deflated bumper; 14, hand ropes.

(Right) A scale in miles showing how far man has been able to ascend into the stratosphere with the aid of scientific equipment.



(Above) One of the huge Diesel-engined, 50 h.p. motor buses that cross the Syrian Desert, a distance of 530 miles, in from fifteen to eighteen hours. (Above, right) The famous submarine *Nautilus* in which Sir Hubert Wilkins will explore the Polar regions. It is fitted with an echograph.

TIM..BER!

—is the Lumberjacks' warning cry, when the big trees begin to fall, all over Canada

Lumbering is the second largest basic industry in the Dominion of Canada and the first in the province of British Columbia. It is the real source of many things commonplace to us all, e.g., newspaper and floor-boards. Canada owning 500-600 million acres of soft-wood timber alone, or about eighty-five per cent of the Empire's timber wealth. Lumbering is essentially a man's business having a considerable element of danger in all its branches. The term 'lumbering' covers all activities from cruising the "limits" (leasehold areas of timber) through the operations of felling, transport and saw-mill delivery of raw wood in various states required by dependent industries.

In this highly organized business, the operations vary only slightly in detail in different parts of Canada. Those prevalent in British Columbia and illustrated here, are typical of all and are up-to-date.

Cutting and transport occupy autumn and winter, except river transport which must wait for the spring thawing of ice-bound rivers. Owing to the hazards of forest fire, operations are closed down at the height of summer. Operating camps are established to plan, and an army of "fallers," "buckers," a "high rigger," "hook-tenders" and engineers, carpenters and rivermen, get busy.

The trees cut are of all sizes up to 15 ft. diameter and up to 250 ft. in height. Occasionally gigantic trees measuring over 300 ft. in height, several thousand years old and all quite sound, beautiful timber have been felled in these regions.

Great use is made of the airplane in the timber country, from the preliminary survey of "the limits," to the quick transport of men and equipment, to remove places and the removal of any injured over country not yet open to ordinary travel. Seaplanes are usually used, for the only landing fields are lakes and rivers, in timber country.

Timber cruisers are the scouts of the lumbering army and work at all times of the year, going into prospective timber limits by canoe, dog-team and plane.

The cruising party travels on foot through the woods, their job being to gather an accurate estimate of the quantity of good standing timber and note the topography of the country with its aids and obstacles, of mountain, river, and previous fires, that so vitally affects the methods of harvesting the timber.

They also suggest suitable locations for camp sites for the operations. The party has to be organized like an exploring expedition, which it really is.

The "drag line." This shows the "hook-tender's" end, as he signals by whistle that the slip cables are now in place and hooked up. The line takes the strain, then the logs weighing many tons, surge forward crashing through the forest debris. In the background a man with a "peevy" manhandles logs into better position for the drag.

The illustration shows three stages in the felling of trees about 8 ft. diameter. Stood about "spring boards" are driven into the base of the tree, clear above the tangle of undergrowth and fallen debris. Standing level on these boards the "fallers" chop a ring of heavy bark from the tree (A) and with a cross-cut saw, up to 12 ft. long, cut nearly half through, at right angles to the desired direction of fall. Steel wedges driven into the cut, after the saw, keep it open for easier work.

Then the saw cut is made, to reach centre about 2 ins. lower than the saw cut, and when nearly centre, the tree (C) cracking like rifle shots, commences slowly to fall, thundering to the ground.

The "buckers" trim off the branches and begin to cut the big stick into desired lengths, two men to a saw, or set the "mechanical bucker" to work (D). The tractor men haul these sections to a skid road of smaller logs (E) and along it in the first stage of transport.

The "high-rigger" has a skilful, hazardous but highly-paid job to prepare and rig the spar tree at the centre of the yarding site. He climbs, for instance, a 200 ft. tree, lopping off branches as he goes up to cut off the top 20 ft. and then hangs on for dear life as the trunk wildly oscillates. His aids are a special rope and waist belt attachment, also leg-irons with long sidewar spurs.

His helper passes up a light connecting rope, necessary tools and the first small pulley, till eventually all the huge pulley blocks and wire tackle are in place.

Yarding. Here is a completely rigged "spar tree" anchored with wire rope to other stumps. At its base is a steam-powered, wood-burning yarder and loading engine, of tremendous power, which is often mounted on a railway flat-car, being manoeuvred into place on sections of portable track.

From its drums run the wire cables and lighter return wires for, sometimes, a quarter-mile radius from the spar tree. All the main wires are shown here, as the top is the long distance sky-line, which overcomes natural obstacles, like canyons and very close stumpage.

Next lower, the "drag-lines." Next the cable "loader."

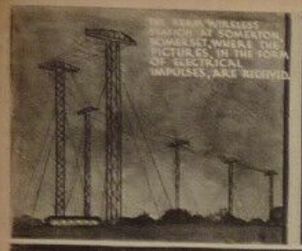
Flumes—of wood or concrete—are built to by-pass high falls, canyons and shallow rapids, often running many miles at a stretch, switching logs from one river to another.

The Davis raft—is a cleverly-constructed solid dovetailed mass of long-length logs chain-bound together, in a colossal cigar shape, many hundreds of feet long. It is designed to prevent the heavy losses from the open booms when voyaging the open sea along the coast in rough weather.

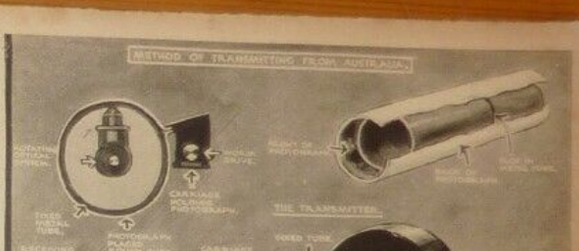
The rivermen daily risk their lives, as soon as the ice has melted. Riding logs is a skilful business, a mistake often means a crushed head or legs, or even drowning, among the plunging logs. Log "jams" are freed by the long pike-pole and dynamite.

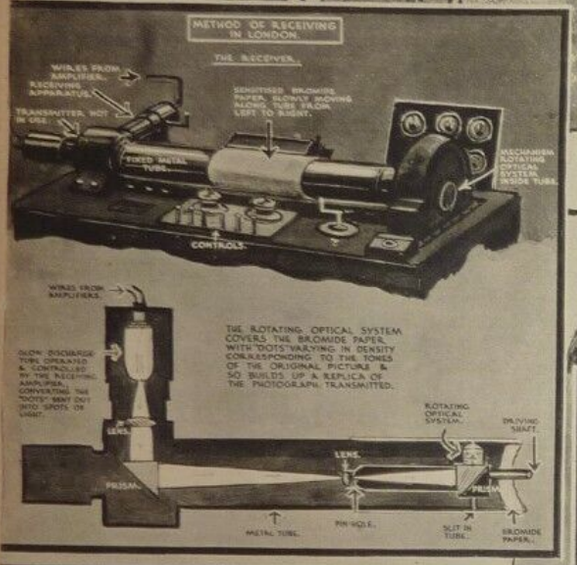
The "log boom." In quiet water where river and salt water inlet meet thousands of feet of logs are steered into each square "frame" of chained boom logs. Eight or ten sections connected can be towed by pecrol and steam tugs.

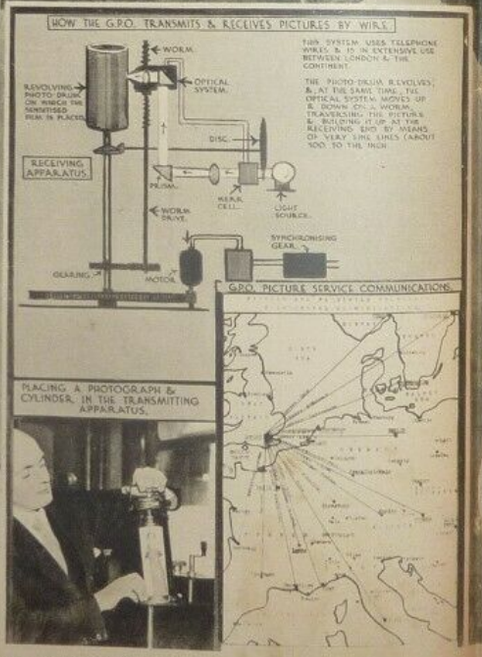
The sidewater sawmill, of the size shown here, includes planing and shingle mills, also with its many employees' families an entire settlement itself. It is packed with very expensive and up-to-date mechanical equipment for the first stages of the raw log's manufacture. A log is shown steered by a pikeman, on the elevator at the entrance to the main mill, for its preliminary squaring up.



THE BEAM WIRELESS STATION AT SOMERTON, NEAR MELBOURNE, WHERE THE PICTURES, IN THE FORM OF ELECTRICAL IMPULSES, ARE RECEIVED.







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SENDING PICTURES MORE THAN 11,000 MILES BY BEAM RADIO

SPEED" is the modern watchword, but even its most ardent advocates cannot travel at a speed which enables news-pictures and cine-pictures to be received in England twenty-five minutes after leaving Australia. Thanks to beam radio, cine films as well as facsimile pictures can be sent half round the world by this means.

When cine photographs are to be sent by radio, they are first enlarged for transmission from Melbourne, and on arrival in London are reduced to their original size for use in ordinary projectors. The picture to be radioed is curled round a fixed metal tube which is divided by a fine slot into two equal lengths and is attached to a carriage which moves slowly along the fixed tube. As each portion of the picture comes over the slot, a spot of light from the optical system rotating inside the tube is focused on the picture.

Similar apparatus is used at both transmitting and receiving stations, and this consists of an operating cabinet, amplifiers and the synchronizing plant.

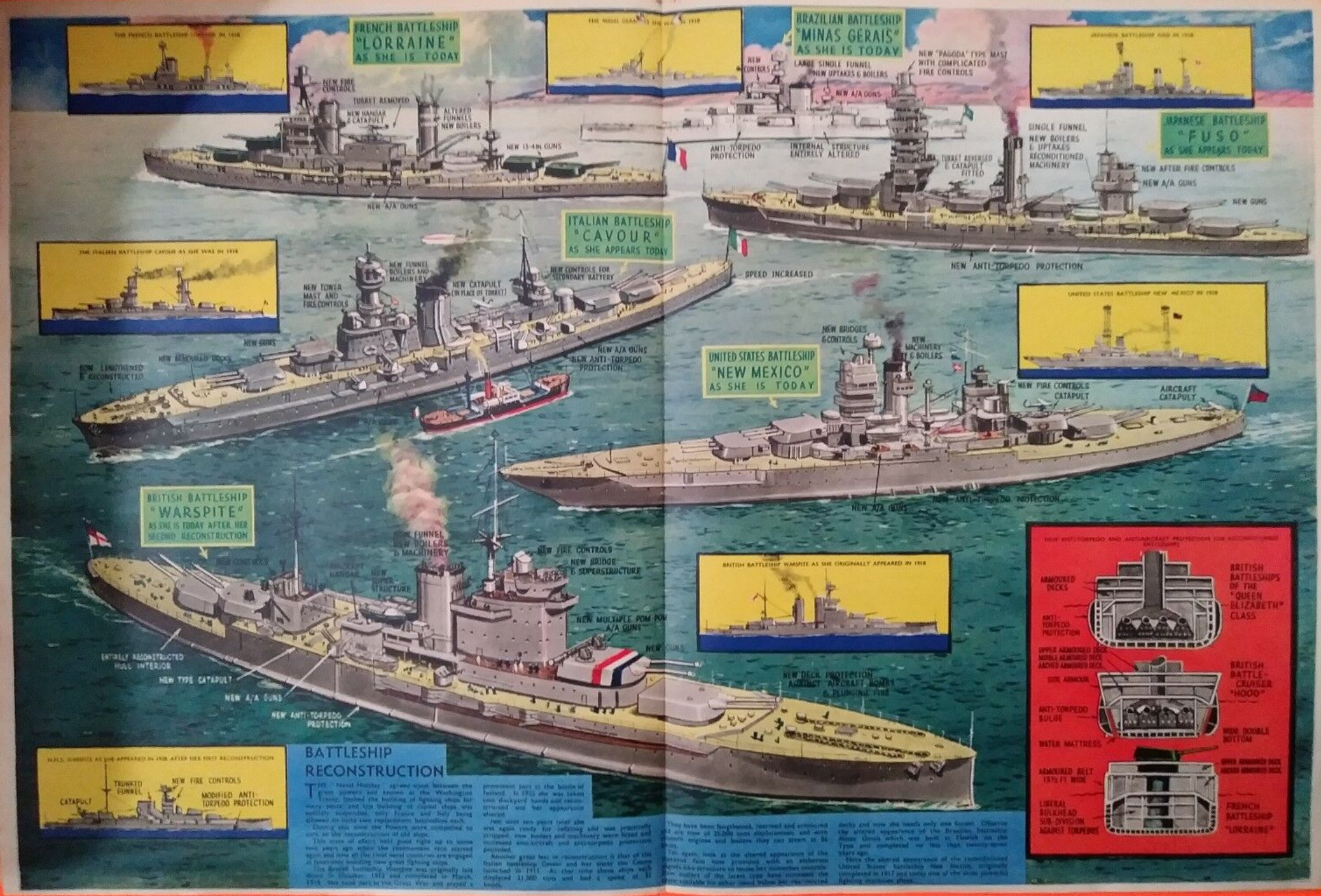
When the little dots of light, which record the tone values of the picture are reflected from the optical system, a series of prisms pass them to a photo-electric cell. They are then converted into electrical impulses of varying intensity, and these impulses are sent by land-line to the beam-radio transmitting aerials, from which they are flashed into space.

Aerials at Somerton intercept these signals at the receiving end and send them by land-line to London where the picture-receiving apparatus, which like the transmitting apparatus also shown above is made by Marconi's Wireless Telegraph Co., transforms the impulses into pictures. This is carried out in a room in which the only light is from a red lamp.

In this room, sensitised bromide paper is placed outside a metal tube on the receiving instrument in which a glow discharge-tube converts the impulses into varying shades of light, corresponding to the tone-shades of the picture. The "flickers" from this glow discharge-tube pass through a series of prisms and lenses to the lens system rotating inside the tube.

As the sensitised paper passes over the slit in the tube, the picture is built up as a facsimile of the photograph being transmitted from Australia. All that remains is for the bromide paper to be developed, and then the picture is complete.

NEXT WEEK - - WONDERFUL DOUBLE-PAGE—IN FULL COLOURS—OF THE FASCINATING STORY OF NAVIGATION



BATTLESHIP RECONSTRUCTION

THE Naval Holiday agreed upon between the great powers and known as the Washington Treaty, limited the building of fighting ships for many years, and the building of capital ships was entirely suspended, only France and Italy being allowed to build two replacements battleships each.

During this time the Powers were compelled to turn to the reconstruction of old ships.

This state of affairs held good right up to some years ago when the rearmament race started again and now all the chief naval countries are engaged in extensively building new great fighting ships.

The British battleship Warspite was originally laid down in October, 1912 and completed in March, 1915. She took part in the Great War and played a prominent part at the battle of Jutland. In 1924 she was taken into dockyard hands and extensively reconstructed and her appearance altered.

Just over ten years later she was again ready for refitting and was practically stripped, new boilers and machinery were fitted and increased anti-aircraft and anti-torpedo protection provided.

Another great leap in reconstruction is that of the Italian battleship Cavour and her sister the Cesare launched in 1911. As they came down each displaced 21,500 tons and had a speed of 21 knots.

They have been lengthened, rearmed and armoured and are now of 25,000 tons displacement and with engines, engines and boilers they can steam at 24 knots.

Yet again, look at the altered appearance of the French Jean Bart, provided with an elaborate tripod-like structure to house her numerous controls. Many battles of the future type have commanded positions suitable for other vessels below but reconstructed decks and now she needs only one funnel. Likewise the altered appearance of the Brazilian battleship Minas Geraes which was built at Elswick on the Tyne and completed no less than twenty-seven years ago.

Since the altered appearance of the reconditioned United States battleship New Mexico, propelled completed in 1917 and today one of the most powerful fighting machines afloat.

Secrets of Nazi Naval and Air Bases

ACROSS THE NORTH-WEST COAST OF GERMANY STRETCH FORTIFIED ISLANDS FORMING HER SIEGFRIED LINE AGAINST INVASION FROM THE SEA. KIEL CANAL, HER LIFELINE TO THE BALTIC RUNS AS A THIN RIBBON OF WATER EXPOSED TO THE WATCHFUL EYES OF OUR DAUNTLESS ROYAL AIR FORCE

COMMENCED in 1887, Germany's sixty mile short cut between the Baltic and North Sea is once more in the news: if only as the hide out for Hitler's fleet.

When first Imperial Germany poured her money into the marshlands of Schleswig Holstein and built the Kiel Canal as a short and safe waterway for shipping, Denmark became an island, and the dangerous passage round the Skaw was no longer necessary to give the German fleet access to the oceans of the world.

In 1904 German naval authorities got a jolt. Their canal, which had taken a number of years to build and a tremendous amount of money as well, was no longer so useful as their fond imaginations had painted it. Britain had just constructed a new type of warship, the dreadnought, and unless Germany was to allow her to construct these new battleships without following her example, the canal would be of little use. The trouble was that there was not sufficient depth for these giant ships. A story current at that time said that Germany would not enter a big-scale war until the Kiel Canal had been doubled in width, and deepened. Construction started in 1908, and significantly, was completed just three weeks before the Great War started in 1914.

Last year Hitler's advisers were still not satisfied with the canal's rise or depth. Thirty-seven feet was considered insufficient depth for warships such as the recently launched *Bismarck*, so a decree was made to again increase the width and depth, and work started immediately.

Since the Nazis scrapped international treaties and permission to pass through the canal was necessary for foreign war vessels a great deal of activity has been carried out in secret. At three mile intervals along the banks of the canal concrete anti-aircraft pillboxes have been erected, and for a long time all photography has been banned, and aircraft have had to fly above 4,000 feet.

Each time German naval experts have got dissatisfied with the facilities offered by their short cut to the Baltic, progress in the rest of the world has passed. Germany's warlords have got their way, and Europe has once again been thrown into a blood bath. That is the reason why Mr. Churchill said after the Great War that he would rather see Kiel Canal neutralized than a thousand Heligolands, and the reason why the closing of the canal to foreign warships has meant the re-establishment of Krupp's Kiel munition works.

The forts which were built to defend the canal before 1914 had to be destroyed under the Treaty of Versailles, but recently they have been rebuilt, and those that have taken the place of the originals were constructed secretly along the most modern lines.

In the last few weeks activity round Kiel has been extended from building naval ships and training their personnel to something which may have an even deeper significance on the course of this war. Germany's continual threats, directed at the Scandinavian neutrals, have taken a new turn with the assembling of troops at Kiel. Fully equipped for land action, these troops are said to be training in embarkation and disembarkation, and with the Baltic about the only outlet for the Nazi Fleet, Germany may decide to use her idle ships in an adventure along the Baltic shores.

WE have heard a great deal lately about the flights of R.A.F. planes over the bases of the German air and sea forces. The Kiel Canal was raided at Brunsbuttel, the southern entrance, on the second day of the war.

In the pictorial views on these pages we show, in some cases for the first time, various aspects of the German island fortresses, and a complete view of the Kiel Canal. Now these islands of the Frisian group all form bases for the Nazi bombers. They also form, as it were, a Siegfried Line of the sea, defending Germany's vulnerable North Sea coast. The three most important are : *Heligoland*, which stands out to sea some 40 miles north-west of the mouth of the River Elbe. *Borkum* to the south, near the mouth of the River Ems and the Dutch coast. *Sylt* to the north, close to the coast of Denmark; Germany's largest island in the North Sea. There are several others of less importance.

Huge sums of money have been spent on the refortification of Heligoland, the island of which the Germans are very proud.

The Kiel Canal is one of the most important strategical canals in the world, it links the North Sea with the Baltic, and has made Kiel one of the great naval bases of the world. In fact, it is the "German Portsmouth." A great German once said "The canal will double the strength of our fleet by enabling us, unseen and unmolested by the enemy, to throw our whole naval force into the North Sea or into the Baltic Sea;" the truth of this remains to be seen.

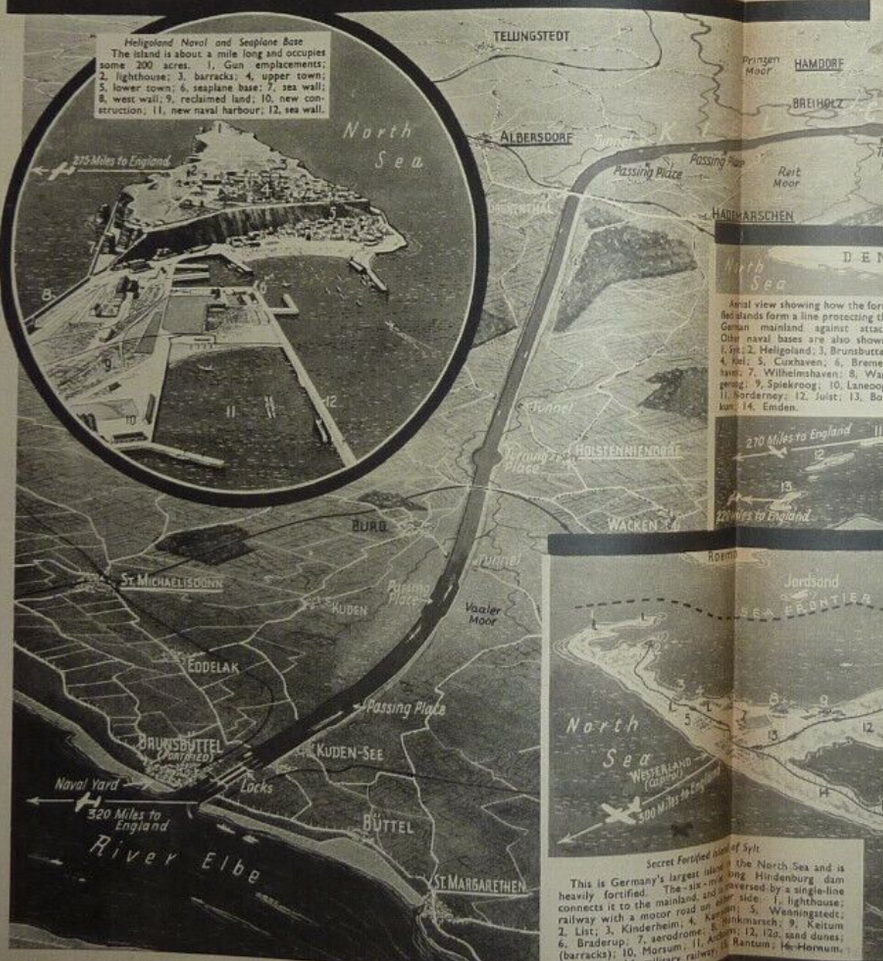
The length of the canal is about 53 nautical miles, approximately 60 land miles. Operated at sea level, it has two double sets of locks at either entrance.

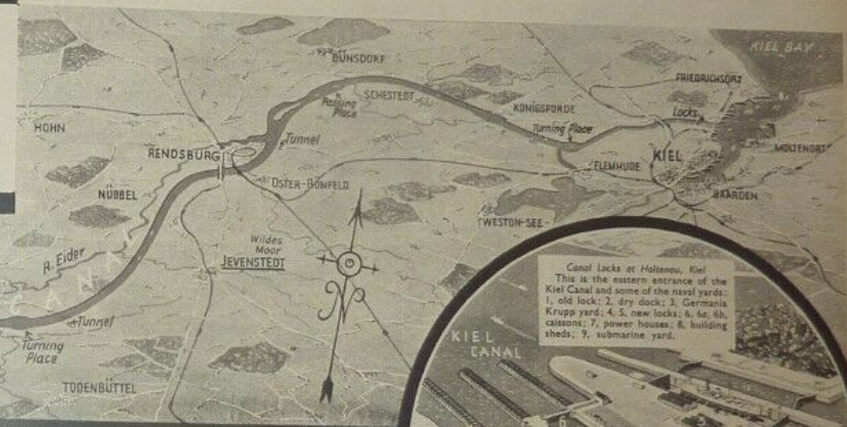
The new locks are 1,082 feet long, 148 feet wide and 39 feet in depth.

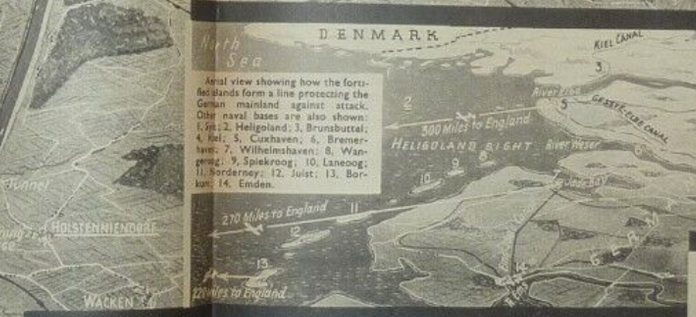
The great German naval yards are at Kiel; the port is divided into four sections. The Old Town Harbour, Ulik Harbour, North Harbour and Vossbrook Harbour.

Brunsbuttel is the southern entrance on the River Elbe and there are also small naval yards there which are heavily fortified.

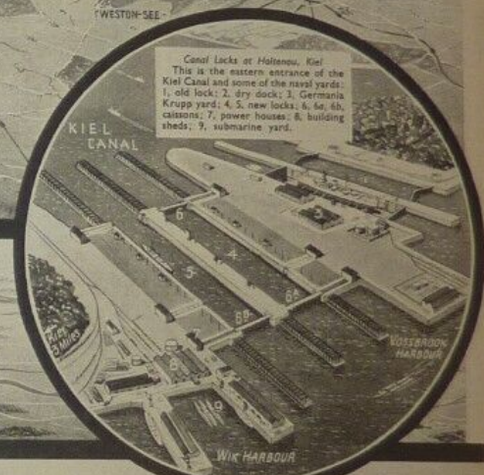
The German nightmare is a British landing on the Schleswig coast. A short advance of 40 miles would bring the British to the Baltic itself and cut Germany off from Danish and Scandinavian supplies.

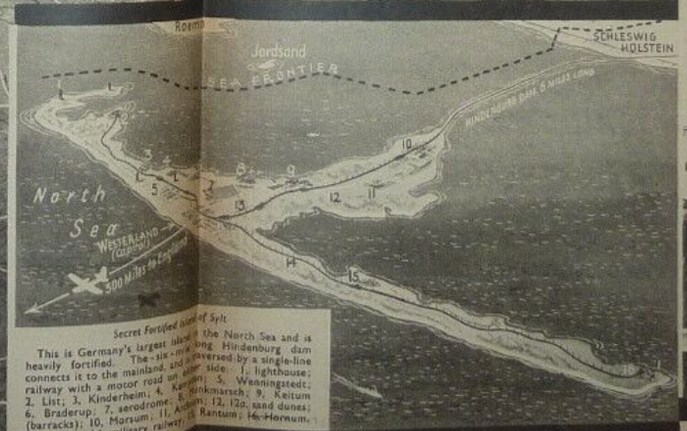






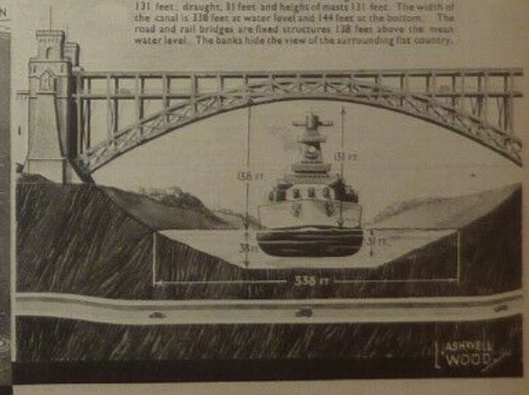
Aerial view showing how the fortified islands form a line protecting the German mainland against attack. Other naval bases are also shown: 1, Sylt; 2, Heligoland; 3, Brunsbuttel; 4, Kiel; 5, Cuxhaven; 6, Bremerhaven; 7, Wilhelmshaven; 8, Wangerog; 9, Spiekroog; 10, Laneoog; 11, Borderney; 12, Juist; 13, Borkum; 14, Emden.

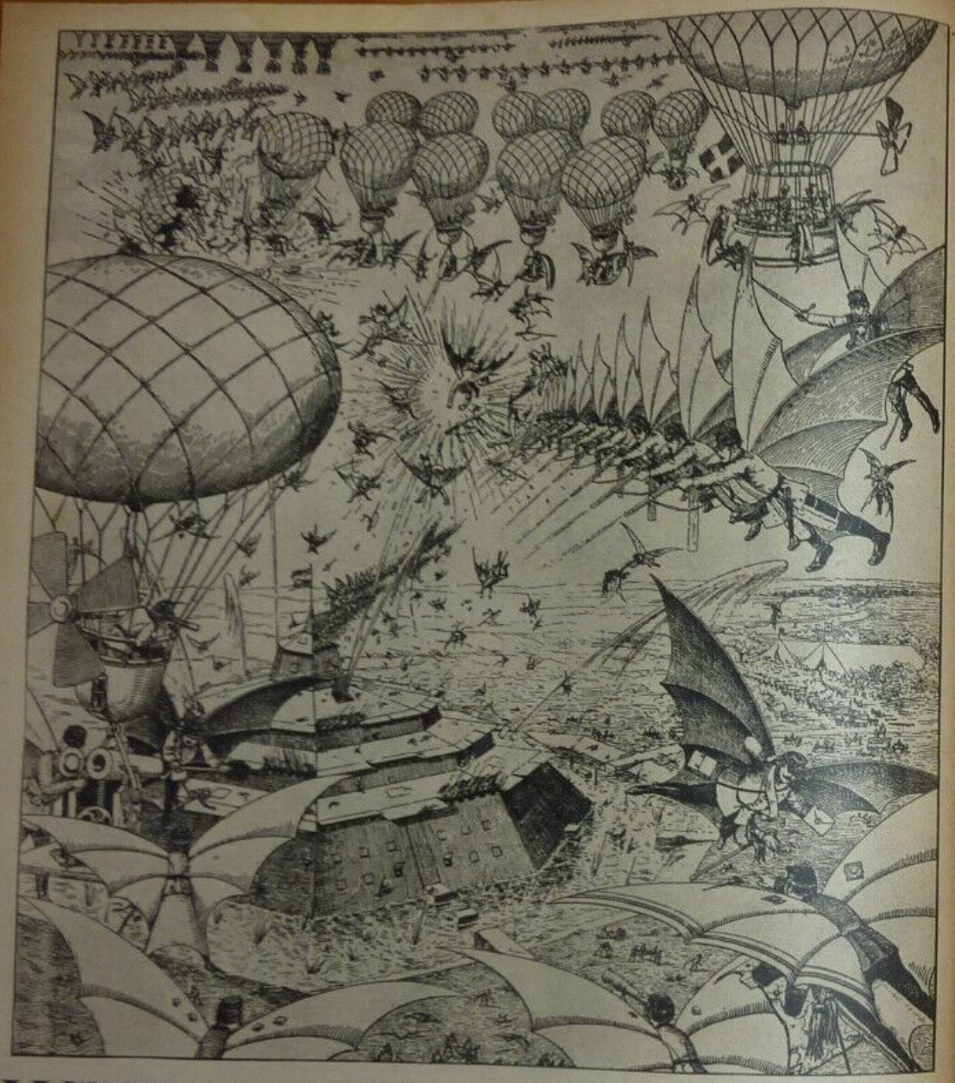




Secret Fortified Island of Sylt

This is Germany's largest island in the North Sea and is heavily fortified. The six-mile long Hindenburg dam connects it to the mainland, and is traversed by a single-line railway with a motor road on either side. 1, lighthouse; 2, List; 3, Kinderheim; 4, Kampen; 5, Wenningstedt; 6, Braderup; 7, aerodrome; 8, Munkmarsch; 9, Keitum (barracks); 10, Morsum; 11, Archsum; 12, 12a, sand dunes; 13, Tinum; 14, military railway; 15, Rantum; 16, Hornum.





Fantastic Dream Comes True!

WAR in the last century was a very different thing to war in these times. In the days of Napoleon, Nelson, Wellington, in the Crimea and Indian Mutiny, war was a thing for heroes. It was like a great game in which every man fought for his country and his honour.

Apart from ballooning on a small scale, flying was as yet unknown. Aerial bombs were unknown. The machine gun was but a contraption, too heavy to move about easily and unreliable in use. Artillery was an uncertain thing and mass attacks by aerial armadas were undreamed of. Thus was the condition and thus were the weapons of war in the nineteenth century.

The above picture was first printed in a prominent Scandinavian journal in 1895. It was intended as an artist's impression of war in the future and in it are included several war weapons which at that time must have been based entirely on imagination, they were pure fantasy.

Since that time, however, conditions of war have vastly changed, and the majority of those weapons which were called fantastic can now be seen fully displayed in the world's two theatres of war.

The modern war is fought in the air. Aerial armadas are no longer a dream. As many as eight machine guns are fitted to our fighter aircraft. But in those days these things were ridiculous.

In certain features it might be presumed that the above picture is even in advance of our present-day wartime conditions. In the foreground can be seen the general staff directing operations while hovering in mid-air—an idea that we in these modern times have still yet to try.

The attack is apparently on some heavily armed fort, from which is issuing in defence what seem to be powerful jets of water or some form of "death ray." Whichever they are, they seem to be having a great deal of success against the aerial infantry and airships in the centre of the picture.

THE above picture is drawn from a more factual basis than its fantastic predecessor. It represents the aerial warfare of today in practically all its aspects and the similarity between this picture and the one on the previous page will be readily noted.

The mass aerial attacks that the unknown artist forecasted are now taking place. Vast numbers of powerful aircraft fill the air. In the single-seater fighter we have what were previously portrayed as flying infantry, all heavily armed with machine guns.

The heavier planes, equipped with cannon and larger bore machine guns, represent what were earlier depicted as airships with heavy artillery.

The inflammable and explosive balloons were hinted at in the 1895 drawing and the wireless method of communication used in these times is surely found in the aerial dispatch rider on the right.

In the central background of the picture we see a mass descent of parachutists such as are being used by Russia and Germany: large numbers of infantry equipped with light machine guns and ready to form into companies for ground fighting immediately on landing. It is highly probable that our nineteenth-century artist intended some of his many balloonists to be landing parties.

If, perhaps, the methods used are not so definitely similar in the two pictures it is astonishing how the general idea corresponds with fact. In the early days of 1895 aerial attack was an undreamed-of thing. The aeroplane was not yet invented and balloon fighting had occurred, although only on freak occasions.

Despite what seemed to be strong facts pointing to the contrary, however, this early artist indicated that aerial attack was coming and that, in fact, it would play a major part in the wars of the future. Like many other men, some of them great pioneers, he pointed to the future and at the time was ridiculed. How right he was we now know.

BRYAN S. McCANN

THE ROMANCE OF THE PORT OF LONDON

SOMEONE once said that the Thames was "liquid history." From the time of the Ancient Britons the Thames has assisted the development of London. The increasing pageant of shipping that has been seen upon its waters, still continues. Each vessel adds a fraction more to the wealth and industry of the world's premier port. Some well-known vessels that have played their part are shown on the left. They are from *left* to right, the *Golden Hind*, built at Deptford; the *Cutty Sark*, famous tea-clipper of the 70's; the *William Fawcett*, the first P. & O. steamship; the *Great Eastern*—the Queen Mary of 1852; and a modern sailing vessel.

On the right are modern types to be seen any day in the Port. From *left* to right, they are: Large refrigerated freighter; a Thames sailing barge; the *Orion*, large passenger liner; a short sea trader; a fruit ship; a modern steam collier; and "maid of all work"—a typical Thames tug.

WINES. At London Docks are the wine and spirit vaults of the Port of London Authority. As soon as the casks are landed they are gauged by means of a rule measurement, to verify the liquid content of the cask.

Chalk marks are then placed on the casks as in sketch. These indicate as follows: D denotes the ship from which the cask was landed. Next is the year and serial number, then the name of the merchant. 58 shows the full contents, or 56 the actual contents. 42 is the cask entry number.

WAPPING
SHADWELL
POPLAR
DEPTFORD
GREENWICH
MILLWALL
BOW
SILVERTOWN
N. WOOLWICH
CHARLTON
BECKTON
BARKING
DAGENHAM
WOOLWICH
PURFLEET
ERITH
GREENHITHE
DARTFORD
TILBURY
NORTHFLEET
GRAVESEND

Fresh fruit is an increasing freight that is being handled by the P.L.A. Every year more and more fruit ships enter the Port of London. These are of specialized construction, having insulated holds and refrigerating machinery, and are nearly all motor-propelled.

KEY TO NUMBERS

1, Insulated holds; 2, Refrigerating machinery; 3, Main engines; 4, Winches on winch house 5, Derricks; 6, Officers' quarters; 7, Crews' quarters; (*inset below right*) shows a portable belt conveyer discharging bananas from a fruit-ship. The direction of the conveyer is indicated by arrows.

Section through a modern warehouse. Swift understung electric cranes travel along trackways across the warehouse. They pick up the cargoes deposited on the quay from the ship and handle it as required, either for storage or transit.

KEY TO NUMBERS—1, Travelling understung crane; 2, Trackway; 3, Loading position to railway trucks; 4, Railway wagons; 5, Light runabout crane; 6, Access to lower floor.

(Below) A typical scene at the Royal Docks entrance. On extreme left a large vessel has just left the lock. On right tugs are swinging a freighter about to enter the lock. In left foreground the waterman's boat waits to pick up the first line to the shore. Right foreground a craft, tug and barge is making for the Royal Albert entrance. A vessel bound up river and a dredger are seen in the centre.

TIMBER. The chief import at the Surrey Commercial Docks is timber. What are known as deal porters unload the ships. They wear a special head-gear known as a leather backing hat, and are able to carry as much as four battens or pieces, about 120 pounds weight.

KEY TO RIVER

1, The Pool; 2, Tower Bridge; 3, London and St. Katharine Docks; 4, Surrey Commercial Docks; 5, Surrey Canal; 6, West India Docks; 7, Millwall Docks; 8, Deptford Creek; 9, Greenwich Power Station; 10, Foreign cruising vessels berth; 11, Royal Naval College and Hospital; 12, Greenwich Observatory, Time Ball and Greenwich Park; 13, Enderby's Wharf; Cable ships berth here; 14, Blackwall Tunnel; 15, East India Docks; 16, Bow Creek and River Lea; 17, Trinity House depot; 18, Royal Victoria Dock; 19, Royal Albert Dock; 20, King George V Dock; 21, Woolwich Steam Ferry; 21a, Charlton, world-famous for manufacture of ships' propellers; 22, Woolwich Arsenal; 23, Entrance to Royal Docks; 24, Beckton Gas Works; 25, Barking Creek; 26, Tripcock Point Lighthouse; 27, Barking Power Station; 28, Cross Ness Lighthouse; 29, Ford Motor Works; 30, Coldharbour Point Light; 31, Erith Coal depot; 32, Dartford Creek; 33, Long Reach; Tavern once famous for prize fighting; 34, Purfleet Oil depot and wharves; 35, New Power under construction; 36, New Thames Tunnel; 37, Tunnel entrance; 38, Stone Ness Light; 39, Cement works; 40, Cadets training-ship Worcester and Cutty Sark; 41, Broadness Light; 42, Training-ship *Exmouth*; 43, Boys' training-ship Worspite; 44, Entrance to Tilbury Docks; 45, Tilbury Docks; 46, Cargo jetty; 47, Passenger landing stage; 48, Coaling jetty.

(*Left*) The P.L.A. maintain a number of wreck-marking vessels. The two green balls indicate that vessels can pass both sides of wreck.

Tilbury passenger landing stage below has every facility for dealing with large passenger liners. Liners bound for docks further up the river disembark their passengers here, to journey to London by train. The landing stage can accommodate the largest vessels, and is well over a thousand feet long. Vessels can use it at any state of the tide. It has a floating pontoon.

KEY TO NUMBERS

1, Vessel alongside; 2, Gangway; 3, Floating pontoon; 4, Covered way to luggage and circulating hall; 5, Luggage and circulating hall; 6, Piers; 7, Screw piles.

GRAIN. Millwall and the Royal Victoria Docks deal chiefly with grain. Large storage granaries are located there. Pneumatic elevators suck the grain from the ship's holds for delivery to large silos ashore. The P. L. A. also have a number of floating elevators in order that vessels can discharge into barges. One of these is illustrated.

KEY TO NUMBERS

1, Suction pipe; 2, Suction pipe with cleaning nozzles; 3, Flexible couplings; 4, Ship's hold; 5, Grain; 6, Vacuum pumps; 7, Air suction pipe; 8, Air exhaust; 9, Receiver; 10, Air trap discharger and motor; 11, Automatic weighing machine; 12, Hopper; 13, Discharge pipe; 14, Barge; 15, Derrick and tackle for mooring pipes.

KENNETH M. SIBLEY

The Royal Docks deal especially with frozen and chilled meat. At King George V Dock, a novel system is employed. Ships can discharge and load simultaneously. Lighters can thus operate on either side of the ship.

KEY TO NUMBERS

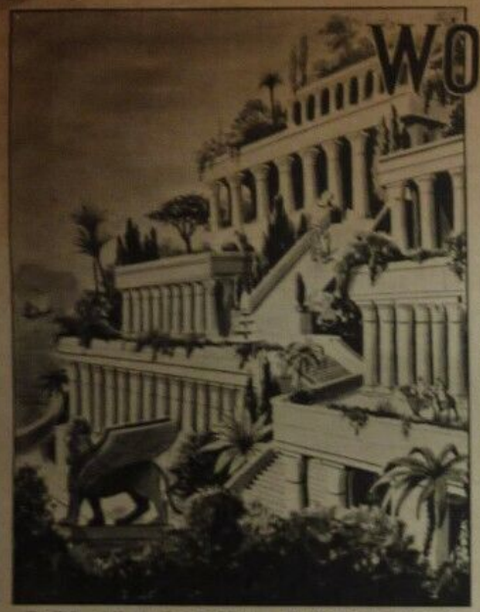
1, Vessel unloading; 2, Decks; 3, Dolphins; 4, Electric luffing cranes; 5, Alternative position; 6, Waterway between quay and dolphin; 7, Lighters; 8, Main quay; 9, Insulated railway vans; 10, Transit and storage sheds; 11, Offices; 12, Insulated vans loading.

Inside the warehouses and transit sheds the carcases of meat are moved as desired by overhead runways traversing the length of the sheds. Automatic weighing machines also weigh the carcases before dispatch.

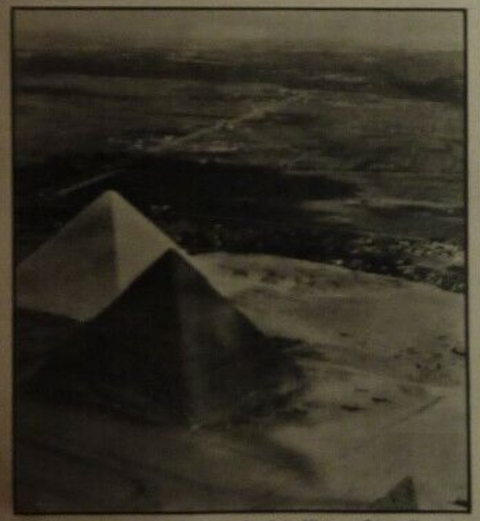
The *London Mammoth* is the heavy-weight lifter of the P. L. A. She can lift loads of 150 tons with a 96 feet outreach. The jib is 220 feet above water-level. She is a self-propelled twin-screw vessel with a length overall of 200 feet.

KEY TO NUMBERS—1, 150 ton tackle and hook; 2, 30 ton tackle and hook; 3, 10 ton tackle and hook; 4, Steam plant working at 150 lbs. pressure; 5, Twin rudders.

Gravesend is the pilotage station for the river. It is also the headquarters of The Port Sanitary Authorities. The larger vessel on the left is the ambulance vessel *Howard Deighton*. She puts out to ships flying the International Code signal L I M, meaning infected cases aboard. The other vessel is the pilot-cutter *Lady Apsley*. She places aboard vessels the river or sea pilots.



The Walls and Hanging Gardens of Babylon. The first garden city was built by King Nebuchadnezzar in the year 600 B.C. Built terrace upon terrace the gardens rose to a height of three hundred feet, giving the impression of trees and shrubbery suspended in mid-air. The walls surrounding the city were eighty-seven feet thick, and an ancient historian records that there were a hundred brass gates. The well which supplied water for the gardens is still there, but all trace of the gardens has vanished.



The Pyramids of Egypt. On the banks of the Nile, near Cairo, still stand the Pyramids which were built by the Kings of Egypt about 3000 B.C. The Great Pyramid, built by Cheops as his tomb, is much bigger than the other two, and 100,000 thousand men were employed for twenty years in its building. In the picture above are two of the Pyramids.

WONDERS *Will*

Throughout the ages the wonders passed on from generation to generation have been chiefly those developed by the skill of the building craftsmen. What of our own wonders? Will they stand the test of time?

• by Bernard HOGBEN

THROUGHOUT the ages man has had many wonderful and amazing things at which to stare, always with an underlying feeling that such astounding examples of art and skill could not be due to the work of men of his own age and generation.

Right through the centuries the prizes for outstanding merit have gone to the craftsmen who produced their wonders in an earlier era, and little time has been spent in studying the developments happening from day to day.

Perhaps there is a reason for this. Maybe the speed with which new wonders are thrust upon the modern world is greatly accelerated compared with the production of outstanding ideas in earlier times.

Whatever the cause, however, the fact still remains that our ancestors have given us the so-called "Seven wonders of the world," whereas our generation can claim to pass on to its offspring a vast store of inventions and scientific developments which may make the wonders of the past look like so much "small change" when reviewed through the distant eyes of history.

If we start to study the wonders of the past in comparison with those of our time we shall soon be struck by the fact that history has pinned fame on the marvels created by the skill of the building craftsmen.

The first of the Seven Wonders—the Pyramids of Egypt—are an example of the most astounding building skill that the world has known. The tremendous masses of stone, hauled by a hundred thousand men employed for twenty years, produced a wonder which has remained a tribute to man's skill since about 3630 B.C.

In those days size and durability seem to have been of major importance, but even then the design of the Great Pyramid was made to conform with its use for the study of astronomy in relation to the life of the people. The Egyptian new year was heralded by the appearance of the rays of the dog star shining straight down the ventilating shaft on to the head of the dead Pharaoh.

The study of astronomy today is carried out with apparatus, which to former generations would seem a wonder of first importance, but to we who live at the time of its development, is taken for granted.

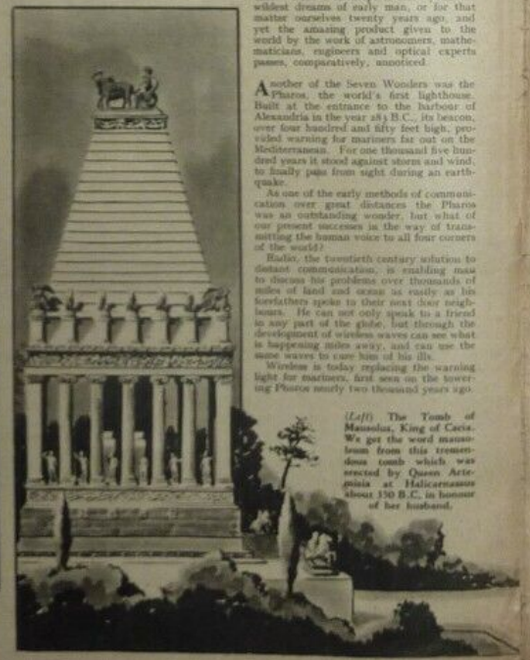
What of the new two hundred-inch colossus of the heavens, which in 1940 will be ready to make the moon appear so near that, through the giant lens, man will be able to observe conditions as if the dead planet were a mere twenty-four miles distant? Such a telescope is far beyond the wildest dreams of early man, or for that matter ourselves twenty years ago, and yet the amazing product given to the world by the work of astronomers, mathematicians, engineers and optical experts passes, comparatively, unnoticed.

Another of the Seven Wonders was the Pharos, the world's first lighthouse. Built at the entrance to the harbour of Alexandria in the year 283 B.C., its beacon, over four hundred and fifty feet high, provided warning for mariners far out on the Mediterranean. For one thousand five hundred years it stood against storms and wind, to finally pass from sight during an earthquake.

As one of the early methods of communication over great distances the Pharos was an outstanding wonder, but what of our present successes in the way of transmitting the human voice to all four corners of the world?

Radio, the twentieth century solution to distant communication, is enabling man to discuss his problems over thousands of miles of land and ocean as easily as his forefathers spoke to their next door neighbours. He can not only speak to a friend in any part of the globe, but through the development of wireless waves can see what is happening miles away, and can use the same waves to cure him of his ills.

Wireless is today replacing the warning light for mariners, first seen on the towering Pharos nearly two thousand years ago.



(Left) **The Tomb of Mausolus, King of Caria. We get the word mausoleum from this tremendous tomb which was erected by Queen Artemisia at Halicarnassus about 350 B.C. in honour of her husband.**

Never CEASE

The talking lighthouse is one of the wonders of the present day world and has the tremendous advantage that it is equally of use in foggy weather.

From the lighthouse tower a gramophone record broadcasts the name of the lighthouse at intervals of seventy seconds, whilst at the same time three blasts on a siren are sent out, the waves from which travel to the ship.

A voice counting at a rate corresponding to the speed of sound through air enables the mariner to calculate his exact position in relation to the lighthouse. When you consider a wonder like this in comparison with the first attempt made to communicate with ships at sea two thousand years ago you will soon realise that our age has marvels of its own to offer, which even familiarity cannot dim.

The tomb of Mausolus; the temple of Diana; the Walls and Hanging Gardens of Babylon; the Colossus at Rhodes and the statue of Jupiter make up the rest of the "Seven Wonders," and the stories of their beauty and the skill which went to their making has been handed down through the centuries.

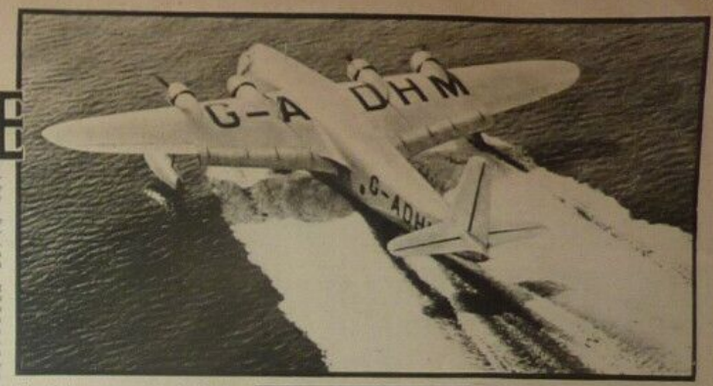
But what of our own wonders? If I was asked to list the wonders of our own time my greatest difficulty would be to avoid leaving some out. So many are being produced right under our noses every day that it is very difficult "to see the wood for the trees." Any list must needs include electricity and aviation; however

And then, of course, printing and modern building must have their places. But then what about steam and petrol engines? Their work for man today is a modern marvel, although we take our train or bus ride very much for granted.

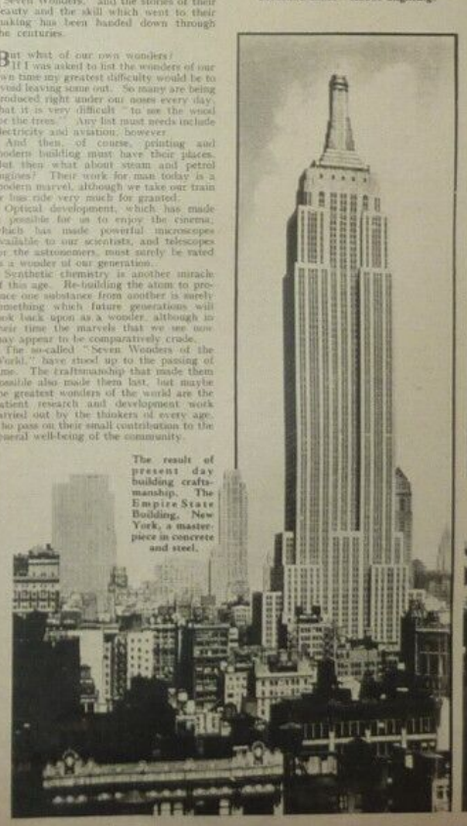
Optical development, which has made it possible for us to enjoy the cinema, which has made powerful microscopes available to our scientists, and telescopes for the astronomers, must surely be rated as a wonder of our generation.

Synthetic chemistry is another miracle of this age. Re-building the atom to produce one substance from another is surely something which future generations will look back upon as a wonder, although in their time the marvels that we see now may appear to be comparatively crude.

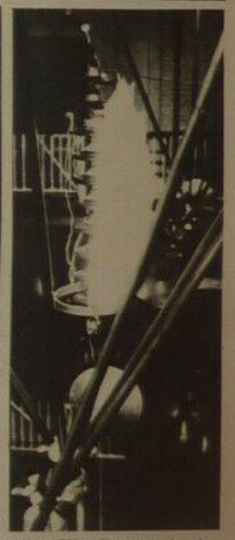
The so-called "Seven Wonders of the World," have stood up to the passing of time. The craftsmanship that made them possible also made them last, but maybe the greatest wonders of the world are the patient research and development work carried out by the thinkers of every age, who pass on their small contributions to the general well-being of the community.



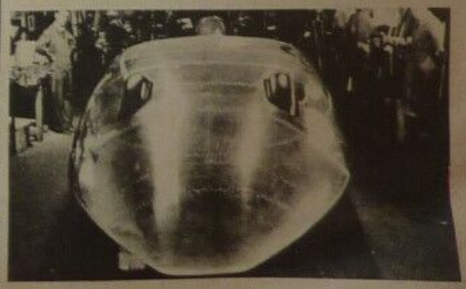
One of the present wonders—the Empire Flying-boat "Caledonia." With a load of nearly thirty people it can race through the sky for a distance of nearly three thousand miles without alighting.



The result of present day building craftsmanship. The Empire State Building, New York, a masterpiece in concrete and steel.



(Left above) **The monster telescope of the Mount Wilson Observatory, through which astronomers study the wonders of the heavens.** *(Right above)* **A high-voltage flash produced by five hundred thousand volts of electricity.** *(Below)* **A modern racing car capable of a speed of three hundred and fifty miles an hour.**



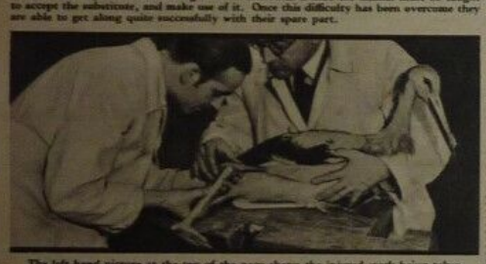
FALSE LEGS FOR STORKS

THE long-billed, heron-like storks found in Europe are usually of the white variety. They inhabit the marsh lands and although rarely seen in England, are commonly found in Germany.

In a recent issue we told you about the repair work that science is making possible for man and domestic animals, but the pictures on this page illustrate a different kind of reconditioning which has successfully been carried out in Hamburg.

Some where in his travels the stork broke his leg. Possibly he knocked into an electricity pylon in his flight. But he was lucky enough to be found by Mr. Schwers, an animal lover, who arranged to have the damaged leg amputated. An artificial leg was made, and the injured stork was once more able to walk.

The difficulty in reconditioning animals and birds is that the animal must be taught to accept the substitute, and make use of it. Once this difficulty has been overcome they are able to get along quite successfully with their spare part.



The left hand picture at the top of the page shows the injured stork being taken by Mr. Schwers to the veterinary surgeon for amputation of the damaged leg. The next picture shows the artificial leg made to replace the real one. Picture immediately above shows the replacement leg being fixed.

Once more the stork is able to stand on two legs, and now it has science to thank for making it possible.

MODERN MIRACLES

for a Penny Seed Packet

By Ralph MICHAELIS

AMONG the miracles of modern mechanism are the machines used by seedsmen and farmers for cleaning flower and vegetable seeds.

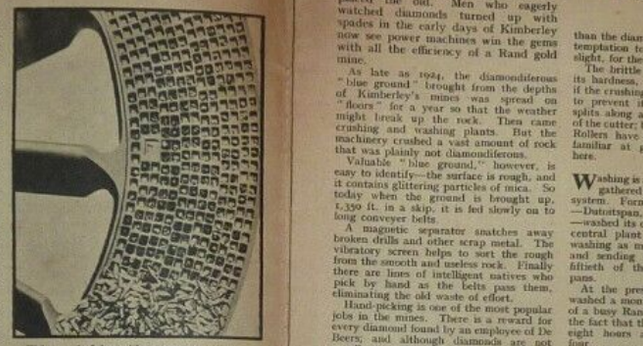
They are so constructed as to separate from the seed, not only dust and dirt, but the seeds of weeds that are inevitably mixed up with the grown seed in the course of harvesting.

The ingenuity of these machines is so fantastic that they can distinguish, not only between one seed and another, but between good seed and bad, or even, when required, between heavy and light seed of the same species.

There is only one distinction that they have been unable to make so far. They do not know the difference between a black and a white oat; but after watching a battery of these miracle machines at work, I am convinced that they will not be long in finding out a means of solving this tricky little problem.

Most seed cleaning is carried out by means of sieves, either vibrating on a plane or rotating in the form of a cylinder, combined with a current of air which blows away the chaff.

All seed before being put on sale has to be submitted to laboratory tests, both for germination and purity tests. It is only the purity test which concerns us in connection with seed cleaning; because if the germination tests are unsatisfactory, the seed cannot be marketed and never gets as far as the machines.



This wonderful machine sorts not only weed from seed, but even good from bad seed.

ONE of the most interesting of modern seed cleaning machines, however, makes no use of sieves, but relies on a number of rotating discs containing indentations which separate the grain required, while rejecting any other seed which has become mixed with it.

This is called the "Carter" Disc Seed-Cleaning Unit.

It consists of two parallel rows of disc separators each with twenty-two indented discs, fifteen inches in diameter. These rows are mounted one above the other and arranged so that the upper machine extracts seeds longer than the grain, and the lower one extracts seeds shorter than the grain.

The upper machine will, therefore, separate oats and barley from wheat, and the lower one will extract cockle, tares, and other small weed seeds.

The machine conducts its process of separation according to the length of the seed. That is to say any seed of different length can be separated; which is the reverse of the principle of separation through sieves, which is a separation made according to the widths of the seeds.

The separation is effected by means of a series of discs revolving in the grain. These discs, which are of hard cast iron, are mounted close together on a horizontal central shaft and enclosed in a dust-tight metal casing. The faces of the discs are indented with hundreds of small pockets, which are undercut so as to retain the grain or seed to be lifted out.

These pockets vary in size and shape according to the separation required, and are made either to pick out seeds smaller than wheat, or to extract the wheat from larger grain, such as barley and oats.

About 50 bushels of wheat an hour can be cleaned on these machines, though the capacity is rather less when cleaning oats or barley for seed purposes. Only about 3 h.p. is required to drive the unit.

WHEN cleaning clover on a disc separator, the indentations on the disc lift out the timothy, but reject quack grass, Canada thistle, small pieces of stick, and the longer buckhorn, which are normally found mixed in a clover harvest.

Some of the machines used for cleaning pea seed are almost fantastic in their ingenuity.

One of them consists simply of a revolving cylinder into which the peas are fed. This cylinder is divided up into three approximately equal sections, the first of which separates the large rubbish, such as poppy heads and stones, the second the small rubbish and the third rejects all peas with worm holes or cracked skins, while a blower blows away all dust.

The third and most fantastic part of the cylinder contains four thousand pins attached to its inside in such a way that they transfix any pea with a wormhole or a broken skin, while brushes moving in the same direction automatically clear the pins of the rejected peas, and sweep them away into a separate discharger. Machines of this type are largely used by the canners.

Another of these fantastic pea cleaning machines consists of a series of horizontal vibrating wire mesh trays, with an air current blowing through from underneath.

The mesh, while being sufficiently small to prevent the peas from falling through, allows all smaller weed seeds and dust to empty itself through them. In addition, this machine is able to distinguish between light peas and heavy peas, which it dismisses by separate exits.

This is effected by means of a blower working in conjunction with a series of parallel metal obstacles running across the sieves, an inch or so apart.

As the peas gravitate towards the right side of the sieve a current of air blows up from underneath, and the lighter peas go hopping over one little obstacle after another until they are evacuated to the right of the machine. The air current is insufficient to lift the heavier peas over these obstacles, and they gravitate towards the left of the machine from which they are evacuated separately.

PEAS to be marketed as seed are usually passed through both of these, or similar machines to those described.

There is an odd device used in separating bits of sticks, and stems, and rubbish from mangel, beet and similar seeds. It consists of an endless carpet made of composition, arranged on an incline and travelling in a direction from the discharge end of the machine towards the hopper. As the seed meets the carpet, the odd stems stick to the carpet and are carried on it to the upper end of the machine from where they are discharged.

It is amazing the amount of weed seed and dirt that is separated by the seed cleaning machines, even from consignments grown under the very best conditions specially for the seed market.

If you were to go up on the "hopper" floor of any of the leading seedsmen, and look at seed pouring down the tubes leading to the machines before cleaning, you would not be able to detect very much wrong.

But there would be a big surprise in store for you, if you were to take a look at the sacks filling up with dirt and dust and weed seed as it comes pouring down the conduits from the machines.

DIAMONDS—

FROM SLUSH

KIMBERLEY always rises triumphant above shocks and depressions. After heartbreaking years, this South African city is astir with fresh hope for the stability of a trade more sensitive than any other luxury trade in the world: *diamonds*.

Ingenious modern machinery has displaced the old. Men who eagerly watched diamonds turned up with spades in the early days of Kimberley now see power machines win the gems with all the efficiency of a Rand gold mine.

As late as 1924, the diamondiferous "blue ground" brought from the depths of Kimberley's mines was spread on "floors" for a year so that the weather might break up the rock. Then came crushing and washing plants. But the machinery crushed a vast amount of rock that was plainly not diamondiferous.

Valuable "blue ground," however, is easy to identify—the surface is rough, and it contains glittering particles of mica. So today when the ground is brought up, 1,350 ft. in a skip, it is fed slowly on to long conveyer belts.

A magnetic separator snatches away broken drills and other scrap metal. The vibratory screen helps to sort the rough from the smooth and useless rock. Finally there are lines of intelligent natives who pick by hand as the belts pass them, eliminating the old waste of effort.

Hand-picking is one of the most popular jobs in the mines. There is a reward for every diamond found by an employee of De Beers, and although diamonds are not usually revealed until the final concentration, the chance of finding one is always present.

The reward is made according to the size of the diamond, at the rate of about 8/- a carat. A native convict labourer once handed in a stone of 268 carats. About half a dozen finds are made on the conveyer belts every month, so that there is no boredom in that department and honesty receives encouragement.

Convicts, incidentally, are no longer employed by De Beers. During a previous visit I was amused to find criminals in red-striped jerseys at work even in the pulsator house, where the diamonds come to light at last.

Officials told me that these prisoners valued their tobacco rations far more highly than the diamonds under their noses. The temptation to smuggle out diamonds was slight, for there was no hope of success!

The brittle diamond would, in spite of its hardness, be in danger of destruction if the crushing machines were not designed to prevent it. Occasionally a diamond splits along a flaw, anticipating the task of the cutter; but there are no serious losses. Rollers have springs. The stamping so familiar at gold mines is never heard here.

WASHING is a stage of production that has gathered greater speed under the new system. Formerly each of the three mines —Dutoitspan, Bultfontein and Wesselton —washed its own ground. Now there is a central plant for the three, capable of washing as much as 12,000 loads a day, and sending out concentrates only one-fiftieth of the ground tipped into the pans.

At the present time 150,000 tons are washed a month, equivalent to the output of a busy Rand gold mine; all this despite the fact that the "blue ground" is hoisted eight hours a day instead of twenty-four.

The pulsator, most spectacular of the mining processes, remains unchanged. It is simply a table covered with grease and shaken steadily as the gravel washes over it with a stream of water. Diamonds are caught in the grease while the worthless gravel passes on.

No one has ever really understood why the device makes this intelligent selection —not even the employee who invented it—but the fact that it works is enough.

When the tables are scraped and the thick mass boiled, the fourteen-million-to-one concentration is complete. That is the ratio. It takes, on an average 70,000 tons of "blue ground" to produce diamonds of about ten pounds.

Sorting now is carried out in the Central Sorting Office in Kimberley. All the large diamond producers of South Africa and South-West Africa send their "parcels" to this well-protected stone building. Not so long ago each company maintained its own staff of sorters and valuers. The Central Sorting Office has rationalized this important section of the industry, besides giving the sorters a wider experience in different types of diamonds.

Here are youths learning one of the strangest of occupations, and middle-aged experts who can tell the origin of a diamond at a glance—and what it is worth.

THEY sit over the shining fortunes in a long row, twenty-three men gripped by the spell of the diamond, the glamour that never wears off. White paper covers the work table. Beside each sorter are the trade's simple tools.

"These are the sieves—the only mechanical things in the office," pointed out my guide on a recent trip. "The diamonds come from a mine in a jumble, and the sieve helps to size them roughly. But after a few shakes the whole process must be done by balance, hand and eye."

Diamonds are cleaned with hydrofluoric acid. They need no other treatment until they reach the hands of the cutter. But what a shuffling and a series of classifications they must undergo before they are ready for shipment to London!

I looked over the shoulders of the sorters. Each man had a pair of tweezers and a scoop, and at times a sorter would reach for the headgear of magnifying glasses to decide a difficult problem.

"It is all done by eye, instinct and experience—a human affair from start to finish," went on my guide. "No machinery will ever replace these men. No text-book on the subject will ever be written. The job can be learned only on the spot, by watching others, and I suppose this room is the finest training ground in the world."

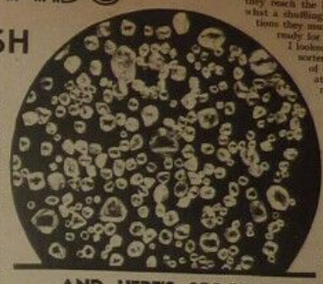
As I walked down the line of sorters, I learned that diamonds are now graded in much greater detail than ever before. A mine's monthly output may be sorted into 1,000 or 2,000 different lots—a task ten times more complicated than the old system of sorting.

IN one heap lay the pick of the output—magnificent blue-white diamonds of the finest shape and purity. Then there were heaps of colours and shades, almost imperceptible variations that affect prices enormously. I was shown a large stone with black flaws so pronounced as to render it almost valueless as jewellery.

Diamonds are found in all the colours of the rainbow, but red is the rarest. Impurities in the crystal may give a diamond a red tinge and increase the price many times—an example of a fault being worth more than perfection.

Green diamonds that cut green are valuable too. The whole art of sorting and valuing diamonds lies in the power to visualise the appearance of the stone after cutting. Even acknowledged experts are liable to errors.

(Condensed from the "Rotarian," Chicago)



AND HERE'S £50,500 WORTH!

SHOOTING TRAINS

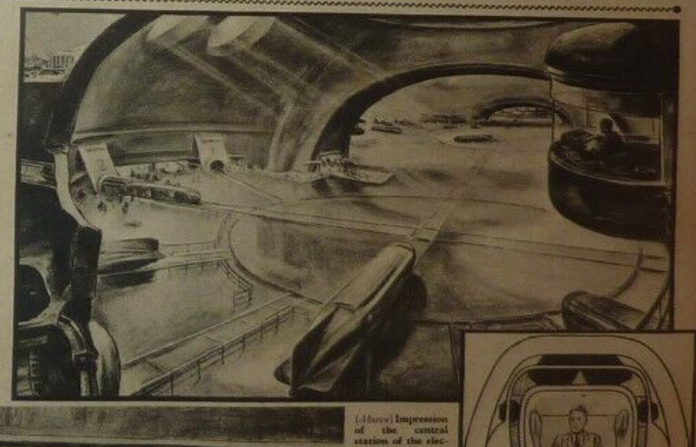
through the AIR

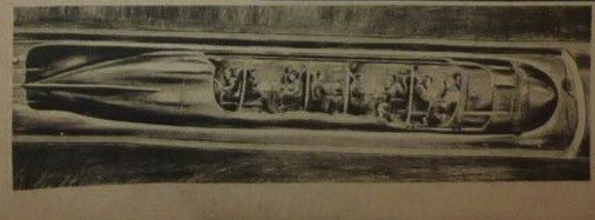
A GERMAN engineer has been able to move a heavy iron body by electro-magnetic attraction through the air in a desired direction. The inventor claims that it will be possible, by his method, to draw torpedo-like trains through air without control rails, at a speed of six hundred miles an hour. The train would make a direct, noiseless, vibrationless flight.

A patent has been taken out at the German patent office, and if and when—at any rate it cannot be for some considerable time—it is put into successful practice, it will mean a complete change in traffic methods.

The constructional costs for such a tube torpedo line, as proposed, would be extremely high. The inventor calculates that it would amount to about £50 a yard. But the exceptionally low upkeep cost should be taken into consideration—replacement of material would be negligible.

However, the invention is interesting and theoretically there is nothing really against the idea.





(*Above*) Impression of the central station of the electro-magnetic tube. (*Left*) Underground tubes are suggested by the inventor, through which air-tight, windowless cars would be run. (*Right*) Passengers sit in comfort at 600 m.p.h.

WORLD'S LARGEST SUBMARINE

THIS French submarine, the *Surcouf*, is the largest underwater craft in the world. She recently captured the German merchant ship Chemnitz in mid-Atlantic and escorted her many miles back to harbour as a prize.

The French were one of the pioneers in submarine construction and in this vessel is concentrated the great experience gained with many experimental types, to which this nation has devoted so much attention.

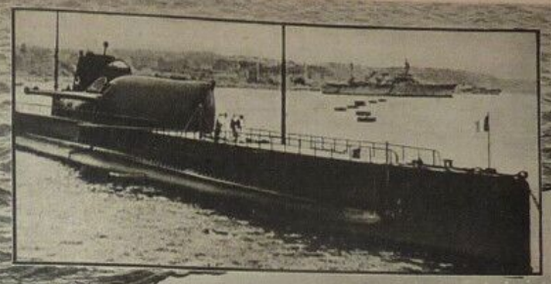
The *Surcouf* also has the most powerful armament of any submarine today. She is practically a submersible cruiser, being armed with two 8-inch guns, as well as two 37-mm. anti-aircraft guns and machine guns. She has ten torpedo tubes, six in the bows and four in two sets of training tubes aft; these are used when on the surface. Twenty-two torpedoes are carried.

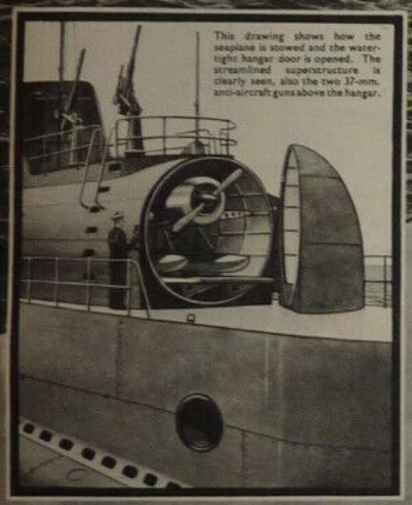
A small seaplane carried in a special hangar is also a part of her equipment. The craft is propelled on the surface by Diesel engines of 7,600 h.p., giving her a speed of 18 knots. Electric motors of 3,400 h.p. give her a speed of 10 knots when submerged.

The *Surcouf* has a submerged displacement of 4,300 tons and is 361 feet in length. She carries a crew of 150 men and six officers. This wonderful submarine can dive in two minutes and remain submerged for a period of two and a half days; the diving limit is 70 fathoms.

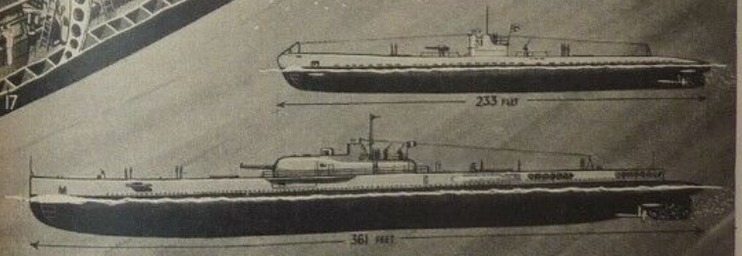
In this drawing we show all her features but the internal structure has been modified to meet the demands of the censor.

France had 101 submarines at the outbreak of war, including fifteen building.

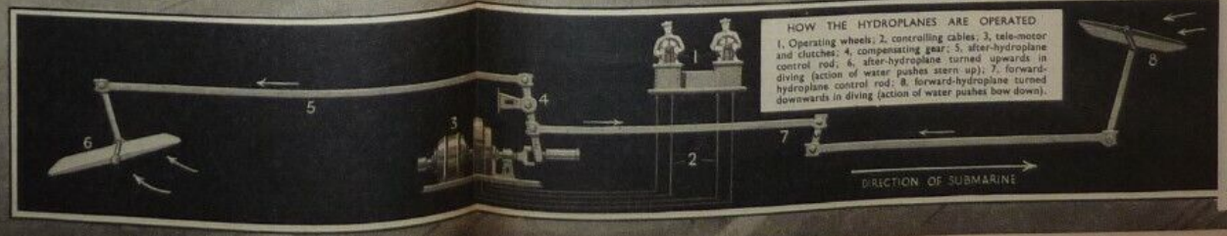




This drawing shows how the seaplane is stowed and the water-tight hangar door is opened. The streamlined superstructure is clearly seen, also the two 37-mm. anti-aircraft guns above the hangar.



An interesting comparison in size between the *Surcouf* and the largest German submarines of the ocean-going class, 750 tons displacement.



HOW THE HYDROPLANES ARE OPERATED

1. Operating wheels; 2. controlling cables; 3. tele-motor and clutches; 4. compensating gear; 5. after-hydroplane control rod; 6. after-hydroplane turned upwards in diving (action of water pushes stern up); 7. forward-hydroplane control rod; 8. forward-hydroplane turned downwards in diving (action of water pushes bow down).

KEY TO PARTS

1. Vertical rudder
2. After-hydroplane
3. Starboard propeller
4. Torpedo tube traps
5. After twin-torpedo training tubes
6. Torpedoes stowed
7. Main electric motors (3,400 h.p.)
8. Switchboard
9. Crew's quarters
10. Twin-torpedo training tubes
11. Position of tubes when used for broadside
12. Hatches closed
13. Main exhaust tank
14. Exhaust outlet
15. Starboard Diesel engine. (Two engines develop 7,600 h.p.)
16. Engine control platform
17. Ballast and fuel oil tanks in double bottom
18. Pressure hull
19. Auxiliary Diesel engines
20. After control room
21. Hydroplane operating gear
22. Oil fuel tanks and periscope well
23. Main control room
24. Upper control room
25. Officers' mess
26. Dynamos
27. Gun-working chamber and trunk
28. Fans
29. Turntable for 8-inch guns
30. Artificers' mess
31. Battery tanks
32. Crew's mess
33. Captain's cabin
34. Forward torpedo flats
35. Starboard bow torpedo tubes
36. Starboard bow torpedo traps
37. Anchor
38. Anchor capstan
39. Forward starboard hydroplane
40. Hatches closed
41. Gun traps closed
42. Twin 8-inch guns
43. Gun turret
44. Starboard navigating light
45. Range-finder
46. Periscopes
47. Conning tower
48. Signal mast lowered
49. Twin 37-mm. anti-aircraft guns
50. Seaplane stowed

LAWRENCE WOOD

Somewhere in FRANCE

WHEN we estimate the strength of armies in the field we do so usually in terms of divisions, for the division is generally accepted as the common unit, very much as the metre is the common unit of the metric system and the acre of our own land area.

But there is one great difference between the division and the examples cited above, for whereas the latter are always constant, the number of men forming an army division and the proportion of infantry to other arms of the service vary with different countries. Even so, it is the division that is invariably cited in estimating military strength in the field.

During the last war, four infantry battalions went to the formation of a brigade, and three brigades to a division. Thus it was always understood that a division included twelve infantry battalions. Nowadays, however, the number of battalions to a brigade has been reduced by one, so that the modern division is composed, not of twelve but of nine battalions.

Four rifle companies are the quota of each battalion, and each of these companies has three platoons. Thus we see that there are one hundred and eight rifle platoons at the disposal of the divisional commander of today. And, unlike the Tommy of the early days of the last war, the very great majority of the men comprising these platoons are specialists.

When the British Expeditionary Force went on active service in 1914, Kaiser Wilhelm dubbed it the "Contemptible Little Army," but what it lacked in quantity was more than atoned for in quality, and the way our men performed miracles with the short Lee-Enfield rifle, proved it to be a force with which even the most powerful adversary had to reckon.

Today, the service rifle still constitutes the cornerstone of infantry small arms training, but a very much greater proportion of the infantry is skilled in the use of other weapons in addition.

Nowadays, our infantry has the Bren gun as its principal weapon, but the short Lee-Enfield .303 is still employed, as are anti-tank rifles.

In addition to its four rifle companies, each battalion has its headquarter company which is more highly mechanized. It includes platoons specially trained in the handling and use of both anti-aircraft weapons and mortars, one platoon that acts as pioneers and yet another that comprises Bren gun armoured carriers.

The purpose of the last named is to provide for the rapid movement of Bren guns when they have to be brought forward into action as a counterblast when the enemy is sweeping portions of the divisional front with heavy fire.

In the last war, the mortars were controlled by a separate battery, each infantry division providing four officers and a hundred men whose duty it was to man the 3-inch Stokes mortars. The larger mortars, such as the 6-inch Newtons, were handled by the Royal Artillery.

The reason why the division is taken as the unit by which the strength of an army in the field is reckoned lies in the fact that it is the smallest military formation in which are included all arms necessary for taking independent action. Also, it is the biggest single unit over which a commander exercises a direct control in the tactical handling of troops in a battle.

Although the numerical strengths of divisions vary according to the different nations, the division is still the standard by which an army's strength is reckoned. Variations in its numbers are caused by the fact that whereas in one army certain units may be on the divisional strength, in others they are attached to army corps and are transferred from one division to another as circumstances may dictate. Thus, in the aggregate, these numerical differences are insignificant.

In the British Army, the division numbers approximately twenty-seven thousand men, and to the infantry there is attached a regiment of anti-tank guns of a considerably more powerful type than those used by the battalions. Also, each division has its own artillery which comprises regiments armed with 25-pounder guns for the direct support of the infantry.

Compared with those of the last war, the normal divisions of today are smaller in numbers, but their fire production is very many times greater. This is an age of specialization, and the soldier of today must know far more than how to handle a rifle and bayonet. Indeed, not only must he have a sound working knowledge of the many different weapons that science has placed at his disposal, but he must also know how to use them to the very best advantage.

To illustrate the latter point, let us assume for the sake of argument that, thanks to the modern weapons the average man can produce a volume of fire ten times greater than could his predecessor of the last war. It stands to reason that if he utilizes that fire ineffectively, he will be ten times the liability that his 1914 counterpart would have been. Therefore, he must know not only how to manipulate his weapon so as to get the maximum fire from it, but he must also employ it to the best advantage.

In other words, the modern soldier must be trained in the use of his weapons to the very best advantage to his unit and he must have far more than a superficial knowledge of fieldcraft.

In this respect, the British Army is second to none, for its men are encouraged to think things out for themselves, and when it comes to the time when a man must use his own initiative, Tommy is never found to be lacking, for one of the soundest principles on which our army is built is that men should be trained to take command if necessity arises, as readily as they take orders from their superior officers.

This ability to rise to the occasion was proved many a time in the last war, and in the grim days of 1914 the fact that a sergeant or corporal could, and did on occasions, command a company with complete success was largely responsible for enabling the first units of the expeditionary force to frustrate the efforts of the opposing German commander, General von Kluck.

Naturally, it is impossible to lay down hard and fast rules as to the disposition of a division in the line, for this must obviously be controlled by local conditions. But it is possible, without revealing any military secrets, to get a general idea as to how the force would be distributed.

Two of the three infantry brigades that constitute the division would probably occupy the front line, while in the support lines that are connected with it by communication trenches, would be the third brigade.

This brigade would be so located that it was as nearly as possible midway between the left and right flanks of the divisional front, so that if reinforcements were called for in a hurry, it would be able to reach any point of its own sector without having to cover too much ground in so doing.

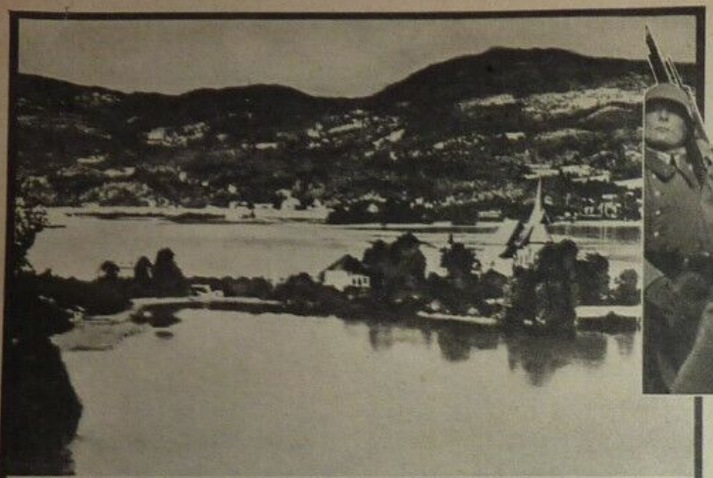
If the nature of the terrain permitted, anti-tank batteries and anti-aircraft batteries could be moved forward close behind the front line and placed in well camouflaged positions which, as far as the anti-aircraft batteries were concerned, would be moved from time to time to prevent enemy aircraft having a chance to locate their positions by the gun flashes which heralded their successful over the line.

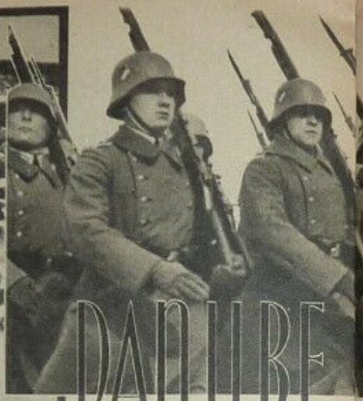
Tanks of the Royal Armoured Corps would also be brought as far forward as safety permitted, and some distance behind the support lines the headquarters of the three brigades would be situated. Field kitchens and field dressing stations would probably be located nearby, and somewhere in the vicinity one might expect to find batteries of the field artillery. Further back would be located the heavy guns and units of the Royal Corps of Signals.

Behind these, the divisional headquarters would be situated, if possible near a railhead and a main road leading to corps headquarters and in direct communication with both the three infantry brigades, the divisional artillery and the Royal Air Force units that are attached to divisional wing.

Thus, the divisional commander can keep in direct touch with all the different units under his command and at the same time maintain contact with the headquarters of the army corps of which his command forms one unit.

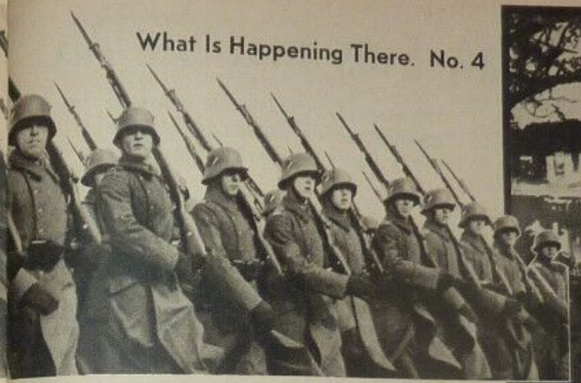
It may seem a simple matter when set down on paper, but organization of the highest order is needed for the successful maintenance of a division in the field. And happily for us, our army has no cause for anxiety on that—or any other—score.

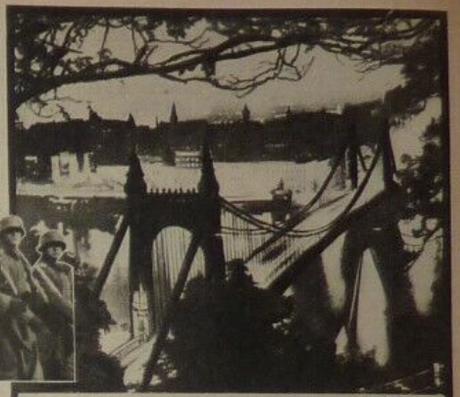




DANUBE

Europe's River of Destiny





THREE dictators stand guard on the Danube, attracted by the wealth of the river which has been coveted for thousands of years. The valley has the richest wheat fields in Europe, the most abundant oil fields. The mountains skirting it have coal and other minerals. The stream is the natural trade route of half Europe.

War shadows overhang the fateful river. On its banks empires have been reared and empires have collapsed. The Danube saw the power of Rome at its zenith; centuries after Rome's fall it saw the House of Hapsburg ruling half the world. The successor of the Hapsburgs, Adolf Hitler, grew to manhood along its banks. He became the master of Vienna. And "Whoever is master of Vienna," Prince Metternich of Austria said, a century ago, "is master of the Danube valley."

Now Russia's giant shadow falls on the Danube. For Russia again is looking westward. Italy still dreams an imperial dream which makes her a contender for a share in the riches of this river. Thus, on the banks of the Danube, the three great races of the Old World—Germanic, Slavic and Latin—meet and clash.

The river flows through five countries, all of which have different traditions and histories. Some months ago it was seven countries. Then the historical tornado struck the Danube valley. The two countries were lost in a few months, and a third country was lost on the outskirts of its basin. How many more nations in its valley are doomed?

Out of the Black Forest a little Danube winds its way into the fairylike world of Southern Germany, past gabled houses and rows of ruined castles. The slender stream is fed by the crystalline waters of the Alps cascading northward and the meandering rivulets of the Swabian hills.

Not far from the river are the Bavarian Alps, in the depths of which a former Austrian, now the ruler of Germany, seeks refuge from the cares of state. Today the German Danube reflects his emblem, the swastika of Nazism, which has set out to conquer the entire valley.

The turbulent waters, piercing the iron-clad defiles of Passau, enter what was Austria, and is now Ostmark. Monasteries and churches are reflected in the stream where rows of hills protect it from curious eyes. It flows on towards the Vienna woods, where Schubert captured the spirit of flowers, Mozart communed with divine harmonies, and Beethoven held converse with titans. The hills on both banks fall away, and there is Vienna, at the intersection of the two natural trade routes of Central Europe: the Danubian Transcontinental highway and the Amber Road.

The Danube leaves Austria behind, an Austria fretting under alien rule, an Austria that now knows what her independence meant. Aggressive kinsmen from the north are hard at work trying to strip the Hapsburgs' one-time realm of its traditional spirit. Will they succeed?

For a few miles the Danube forms the southern boundary of Slovakia, once a co-partner in the republic of Czecho-Slovakia, an experiment in democracy. It is a country of tall mountains and quiet shepherds, uneasy under Nazi rule. Then the mountains recede, and the Danube widens out, accepting the angry waters of the Carpathian range.

Now the waters nourish the black soil of Hungary, growing the richest wheat of the valley. The great Hungarian plains stretch away to the steel-blue horizon.

Budapest is a Hungarian rhapsody. More than a mere capital, it is the quintessence of the Hungarians' creative energy. In its incomparable setting of hills and sommolent waters, it has beautiful buildings and an enchanted island. The city reflects Hungary's pride and grief—pride of an old kingdom and grief at the loss of its territory at the peace conference. As modern as tomorrow, Budapest is the capital of the last feudal country in Europe.

Only the frontier markers tell us when the Danube enters Yugoslavia, yet here it flows into another world. That modern city on top of a bold bluff is Belgrade, the capital, a mere oriental village a few years ago.

Here the Danube becomes the northern frontier of the Balkans, the bloody peninsula. For centuries Yugoslavia fought the alien oppressor, and now again she is confronted with grasping neighbours. She is in a key position, between the East and West. Her grain is good, and her copper, zinc and iron ore are standing temptations to dictators.

Flanked by forbidding mountains, the Danube is about to leave the world of the Germans, Magyars and Slavs, on its way to the interior of Rumania. Exhausted in the long journey, it looks like a tired old river. Europe's largest oil fields are to the north. On the outskirts of the Orient, it is the centre of an occidental culture, symbolizing Rumania's conflicting loyalties to East and West.

The dark Balkan mountains run parallel with the river on the south bank. Then there is Bulgaria, on the highway of many conquerors. The war left her despoiled of many treasures and she conceived a deep distrust of the victors. Germany called and Bulgaria heard the voices; now she has stopped to ponder.

Swinging northward into Rumania the Danube now approaches the immense expanse of its reed-covered delta. Before reaching the sea, it looks upon Bessarabia, where the Russians ruled until the end of the World War. The Soviets have never recognized Rumania's title to this part of their pre-war empire.

In the delta the hunter and fisherman live a life which must have changed little since Abraham's time. Here it is difficult to realize that the Danube has its rise near the border of France. France, over by the Black Forest, seems to be in another world as we approach the Black Sea.

Great rivers often invest a region with common aims. The Volga helped Muscovy to subdue a medley of races. The Rhine links up related cultures, even though part of it divides belligerent countries. The Seine is Latin, the Elbe is German, the Thames is English. The Danube has no nationality.

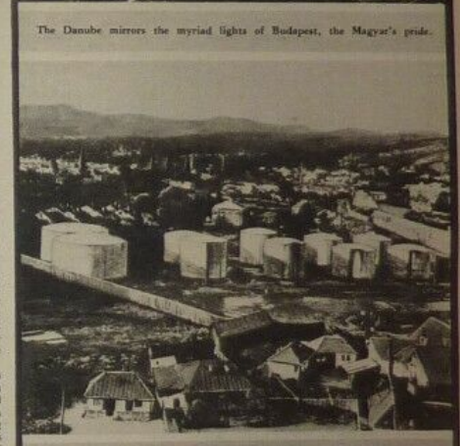
A Hungarian-speaking policeman hastens to a scene of an explosive quarrel. An Albanian public porter, wearing his typical white skull cap, punches the nose of a turbaned Turk because of a Greek travelling salesman's tip, while a gipsy beggar looks on unconcerned, and a crowd composed of Kutzo Vlachs, Macedonians, Bulgarians, Croats, Montenegrins and Sephardic Jews watches the fisticuffs.

A village of the Danube may speak German, its neighbour Serbian and another neighbour Rumanian. Ten dialects and languages may be spoken within a radius of ten miles.

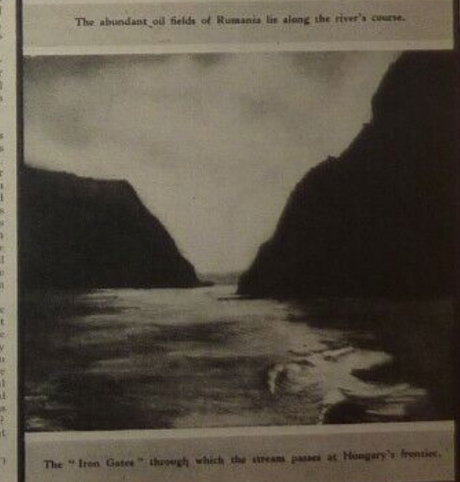
At the time of the wanderings of peoples the Danube was one of the two highways by which Asia was pouring into Europe. Later it attracted the Romans in their search for world dominion. It showed them the way to what they believed was the end of the earth. Then the Asiatic Magyars obtained a foothold. The Hapsburgs arrived in the thirteenth century and, with Vienna as their base, extended their rule eastward. The Ottoman Turks challenged the Hapsburgs' power and kept part of the Danube valley in bondage for more than four hundred years.

The tragic river is true to its part. The nations in its valley see the danger that threatens to engulf them. They have done their best to settle their problems by peaceful means—a miraculous attempt in this part of the world. Who could have foretold that Serbian and Bulgarian would live as two meek lambs? Who could have foretold that even the Hungarians would forego the pursuit of their aims? The Danube valley is peaceful today, but its peace is that of fear.

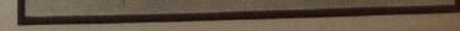
(Reproduced from the "New York Times Magazine")



The Danube mirrors the myriad lights of Budapest, the Magyar's pride.



The abundant oil fields of Rumania lie along the river's course.



The "Iron Gates" through which the stream passes at Hungary's frontier.

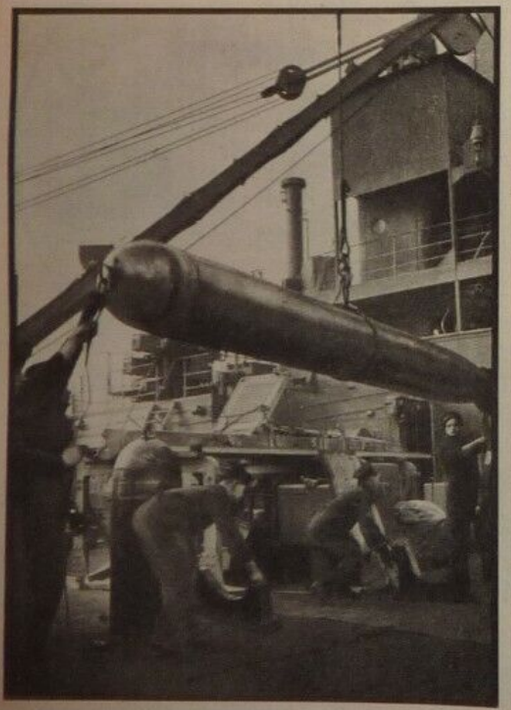
SUBMARINE HOTEL — FLOATING WONDER WORKSHOP FOR THE NAVY!

KEY TO SECTIONAL VIEW

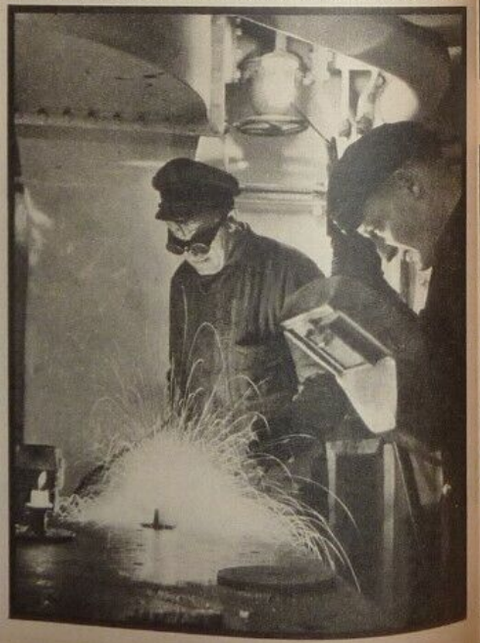
1, Capstans; 2, forward twin 4.5 high-angle guns; 3, navigating bridge; 4, director tower; 5, chart house; 6, cabins; 7, blower cabin; 8, 27-ft. whaler; 9, periscope examining room; 10, seamen's mess; 11, scullery; 12, serving room; 13, seamen's wash place; 14, cold store; 15, submarine crew's mess; 16 and 17, stores; 18, telephone exchange; 19, lobby; 20, torpedo warhead room; 21, steel room; 22, light machine shop; 23, submarine crew's mess; 24, chief petty officer's mess; 25, canteen; 26, 8-ton electric crane; 27, bakery; 28, copper-smith and foundry shop; 29, stores part store; 30, plate shop; 31, heavy machine shop; 32, distilling room; 33, smithy shop; 34, workshop vents upcast; 35, compressed air bottle room; 36, 3-pounder; shotlight; parapet; 37, periscope device; 38, 36-in. searchlight (port and starboard); 39, workshop ventilation funnel; 40, gyro compass room; 41, galley and kitchen; 42, twin 4.5 high-angle guns (port and starboard); 43, boiler room vent; 44, boiler uptake funnel; 45, engine room vent; 46, tripod mast; 47, director tower; 48, officer's gallery; 49, cabins; 50, torpedo stores; 51, engineers' mess; 52, recreation space; 53, air compressors; 54, 4.5 magazine; 55, generators; 56, boiler room; 57, boiler uptakes; 58, engine room; 59, fuel tanks; 60, switchboards; 61 and 62, chief petty officers' washing places; 63, wireless/ring room; 64, dental surgery; 65, sick berth; 66, officers' cabins; 67, 28-ft. motor boat; 68, 45-ft. motor boat; 69, 30-ft. whaler; 70, 32-ft. motor boat; 71, officers' baths; 72, officers' saloon; 73, wardroom officers' baths; 74, officers' fresh water tanks; 75, medical stores; 76, mortuary; 77, after twin 4.5 high-angle guns; 78, starboard propeller; 80, rudder.

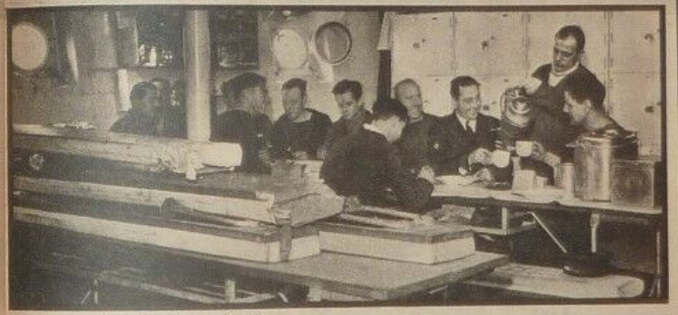
WHAT happens to the crews of submarines after their patrol is completed and they need a hard-earned rest? The answer is found in Britain's latest £1,000,000 submarine depot ship. For days at a time the men of the submarine service make their way beneath the waves in search of the enemy. When the time comes for rest for men and overhaul for machinery, they draw alongside their mother ship and the crew get a spell of comfort in place of cramped quarters.

Besides rest rooms and comfortable quarters the submarine crews have their own mess rooms and lockers, and are able to enjoy home comforts for the few days required to recharge and refuel their craft. On board the depot ship there are some five hundred skilled naval craftsmen, who, in up-to-date workshops aboard, are able to make or repair any part that may require attention. As the submarine crew come aboard for their spell of rest, swarms of mechanics take charge of the craft to effect repairs and refuel her, ready for the next patrol.

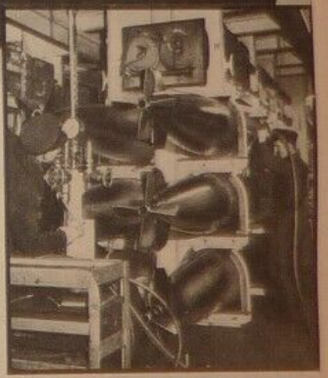


On board the depot ship are collected an amazing assortment of stores, food, fuel and ammunition. The mother ship has got to be prepared to supply every need of the nine or so submarines attached to her, and in this picture you see her taking on board a torpedo which will eventually be taken aboard one of the submarines.

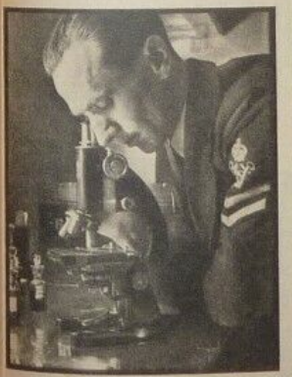




Returned from a patrol, men of a submarine crew enjoy a meal at their own table which is reserved for them whilst they are away on duty.



Charging torpedoes with compressed air is a last-minute job, and naval ratings are seen in this picture charging the "tin fish" aboard the depot ship.



The sick bay is equipped on modern lines, and in the bacteriological laboratory petty officers carefully examine specimens under powerful up-to-date microscopes.

[Left] In the modern repair shops aboard the depot ship, naval-trained welders carry out any repairs that the strenuous patrols may make necessary to a submarine.

The community aboard the mother ship averages 1,200 men, and the sick bay, with doctors and a fully qualified staff, is prepared to deal with any case that comes along, whether illness or wounds.

EXPERIMENTING WITH

TRANSATLANTIC ROCKET TRAVEL

By Bryan S. McCann

The rocket is shot and proceeds to soar. Fins are fitted for stability and to keep the nose pointing in the direction of flight. The greatest height recorded by these models is 2,500 feet.

The American Rocket Society is now building and experimenting with models of Transatlantic Rockets of the future

EVER since the days of Jules Verne the world has dreamed of rockets as fantastic machines specially designed to carry passengers to the moon or other planets, in a matter of a few hours. Despite repeated denials by men who have adopted rocketing as their science, these dreams still exist. And with them they create rumours, stories of men building rockets ascending twenty, fifty, one hundred miles into the air, of men climbing into rockets and piloting them on their flights. All of this is purely fantasy, wild dreams based on conjecture and hopes.

When we come to face facts and see exactly what is being done in rocketing, we realise that before man can build a rocket that will so much as travel across the Atlantic there are many years of research to be undertaken.

The American Rocket Society for this reason adopted its new name—at one time it was known as the American Interplanetary Society—and is concentrating on building and experimenting with model rockets. A certain amount of full-size experiment still goes on but owing to financial reasons and certain technical difficulties this is very limited. Research with models is cheaper and more efficient, the chance of failure being considerably less.

Britain, France, America, Russia, Germany, Austria, all have their rocket societies, made up from men who are scientists and technicians during the day time and at night expend their time and money on building and "shooting" rockets.

A recent report of the British Interplanetary Society states that designs for a space ship capable of not only taking off from the earth's surface, but also of landing on the moon, have already been completed and published. The cost of the machine would be £250,000 and ninety per cent of the mass of the vessel would be fuel, leaving exactly two tons as a paying load.

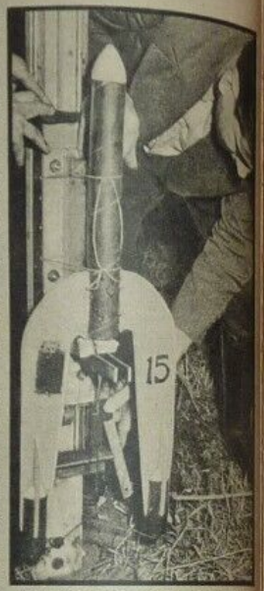
Technically it is claimed there is very little difficulty in building a machine capable of interplanetary flight. The two chief requirements of this type of flight are a method of propulsion that will operate in a vacuum of space and also a supply of energy sufficiently great to overcome the tremendous gravitational forces involved in such flights.

Owing to the war much of the work has been considerably curtailed, but the American society still carries on. It is at the moment experimenting with models of larger rockets which it is hoped to send across the Atlantic carrying freight. These journeys are already visualized by senior members of the society as being possible and of being made in an hour or less.

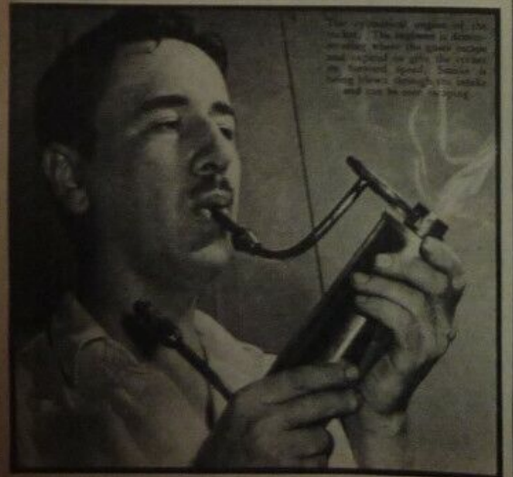
No mention is made in American reports of interplanetary rockets. Research has not yet reached the stage where such a thing can be reasonably contemplated.

The rockets are powered by cylindrical engines using alcohol as fuel, and the forward motion of the rocket is obtained by the expansion caused by the escape of gases from the "exhaust" at the very rear of the rocket. This expansion creates a back thrust and a pushing power behind the rocket, thus creating forward speed.

One last word about rockets. It is interesting to note that a rocket engine gets fifty per cent of the power out of the fuel, while the most efficient petrol engine in production gets only thirty per cent of the possible power out of its fuel.

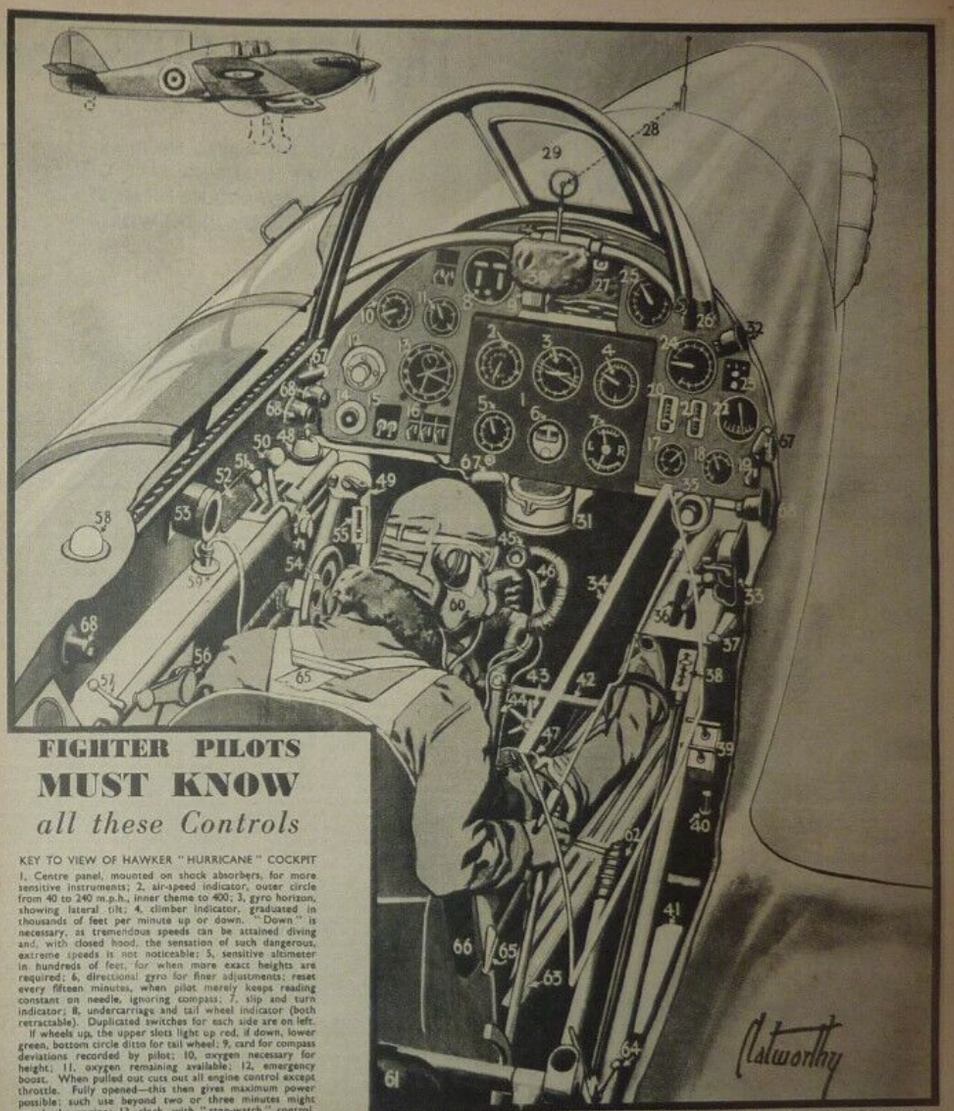


(*Above*) The rocket is fixed to the carriage and is ready to be catapulted into flight.



The experimental engine of the rocket. The engineer is demonstrating whether the gases escape as they should do after the cylinder has been fired. Special fuel is used, being blown through the nozzle and can be seen escaping.

Some of the many designs of rockets with which the American Rocket Society is experimenting. At the present moment the society is concentrating on building models of rockets of a type that it is hoped will one day be able to cross the Atlantic as freight carrying machines.



FIGHTER PILOTS MUST KNOW *all these Controls*

KEY TO VIEW OF HAWKER "HURRICANE" COCKPIT

1, Centre panel, mounted on shock absorbers, for more sensitive instruments; 2, air-speed indicator, outer circle from 40 to 240 m.p.h., inner theme to 400; 3, gyro horizon, showing lateral tilt; 4, climber indicator, graduated in thousands of feet per minute up or down. "Down" is necessary, as tremendous speeds can be attained diving and, with closed hood, the sensation of such dangerous, extreme speeds is not noticeable; 5, sensitive altimeter in hundreds of feet, for when more exact heights are required; 6, directional gyro for finer adjustments; reset every fifteen minutes, when pilot merely keeps reading constant on needle, ignoring compass; 7, slip and turn indicator; 8, undercarriage and tail wheel indicator (both retractable). Duplicated switches for each side are on left. If wheels up, the upper slots light up red, if down, lower green, bottom circle ditto for tail wheel; 9, card for compass deviations recorded by pilot; 10, oxygen necessary for height; 11, oxygen remaining available; 12, emergency boost. When pulled out cuts out all engine control except throttle. Fully opened—this then gives maximum power possible; such use beyond two or three minutes might wreck the engine; 13, clock, with "stop-watch" control. Also button to return second hand to zero, with small dial hand, which then totals up period of flight exact to one second; 14, electric starter; 15, magneto switches; 16, navigation light switches; 17, oil temperature (yellow); 18, radiator temperature (blue); 19, magneto switch; 20, oil pressure (yellow) 21, fuel pressure (red); 22, amount of fuel; 23 switch for 22 with three positions, lever above giving readings for port, centre and starboard tanks; 24, boost gauge (red); 25, revolutions indicator; 26, reflector sight switch; 27, dark slide of reflector sight for guns.

A red circle is thrown on it as a screen with a red dot which must be kept as its centre; 28, usual ring and bead sights; 29, flat glass panel; 30, crash pad preventing injury to pilot's head in bad landing; 31, compass; 32, reflector sight dimmer; 33, recognition lights switch, with morse key; 34, outline of emergency exit. A pull on the wire unlatches the panel, which is then held only by adhesive tape, and can be readily burst open; 35, primer; 36, four-way selector box to raise or lower wheels and flaps.

Flaps are under wings and are lowered to reduce landing speed; 37, lever to engine drive for same; 38, flaps indicator showing their position; 39, firers for forced landing flares at both wing tips; 40, safety stud for lowering wheels if other devices fail. It is pressed down by foot; 41, window, observers; 59, oxygen plug; 60, oxygen and radio telephony mask; 61, oxygen bottle; 62, handle of auxiliary pump (hydraulic) for wheels and flaps; 63, seat height adjustment lever; 64, Sutton harness locking lever, tightens or slackens harness when pilot needs to bend forward; 65, Sutton harness binding pilot to seat. All four cross straps latch on one bolt at his chest, secured by spring pin.

One cut on this instantly releases the pilot in emergency; 54, tail-trimming wheel; 55, radiator shutter position indicator. The shutter lever is hidden here, being by the pilot's left side; 56, landing lamps tilting lever; 57, locking lever for sliding hood shown enclosing cockpit; 58, recognition lamp to flash morse identification letters to aircraft above. There is another below fuselage for ground observers; 59, oxygen plug; 60, oxygen and radio telephony mask; 61, oxygen bottle; 62, handle of auxiliary pump (hydraulic) for wheels and flaps; 63, seat height adjustment lever; 64, Sutton harness locking lever, tightens or slackens lever; 65, Sutton harness when pilot needs to bend forward; 65,

FLOATING BARRICADES of DEATH

GUARD OUR SHORES

The navigating officer guides the ship to the minefield, and then plots the exact position of the field sown.

A SIMPLE announcement in the Press which tells that the navy is laying a new minefield along the shores of Britain probably doesn't mean much to the average reader. Just another routine precaution, necessary to safeguard the country against indiscriminate U-boat warfare. But to the men who do the job of laying the mines, most of them but a few months ago engaged in ordinary peace time occupations, it means a grim hazard: a constant gamble with death.

A wide assortment of men get together in the various craft that take up the business of building the carefully laid defence walls surrounding our coasts. Merchant seamen, some of them; reservists who a short time ago were driving buses or delivering our letters; men of the Royal Navy and fishermen. Real skill is needed for this job, and above all, *iron nerves*.

Hundreds of loaded mines, filled with T.N.T., are a nerve-wracking enough cargo in themselves, but add to that the hazards of a chance bomb from enemy aircraft, or a submarine lying in wait at the minefield; and it doesn't take much imagination to realize that the men who do this work need to be of the type that has made our navy what it is today.

Most people would say that mines came into use first during the Great War, but they have had a much longer history than that. In the sixteenth century floating charges of explosives were used to blow up bridges and ships at anchor. Later, in the American Civil War, development of this weapon was taken further, and several ships experienced a foretaste of the horrors of modern warfare; although to give credit where it is due, it must be added that warships, not innocent merchantmen, were the victims.

The use of mines is a legitimate form of warfare; that is, when it is employed in its proper form. By international treaties the position of minefields must be notified to shipping so that precautions can be taken for avoiding the affected zone. Britain abides by this condition in laying her minefields, but the Nazis use this weapon, to express it in their own words, as a form of "total warfare." Which is just another way of saying that they intend to make barbarious warfare on anything that can't hit back.

During the Russo-Japanese War of 1904-5 both sides used mines, and in the defence of Port Arthur heavy losses were inflicted by both sides. In 1863 mines were introduced into the British service, and although a marine weapon, were put in charge of the Royal Engineers. As the use of mines became more widespread, two types were developed. The first kind, useful for sowing at the mouth of rivers or to guard the entrances to harbours, was known as controlled. Exploded by electricity from the shore, this type is only suitable for use where enemy ships can be observed when they enter the mined zone.

For building up the defensive mine barriers round Britain a semi-controlled type is used. Exploded by contact with the hull of a ship, there is a safety device which operates to render it harmless if the mine breaks away from its mooring rope. A novel type of mine used by the Americans during the Great War employed a thirty-five feet long antennæ, which resulted in extending the effective area of each such mine.

With British naval supremacy over the Nazis in no shadow of doubt, it is understandable Germany should depend on mine warfare to a far greater extent than we do. Few of her ships dare show their flag on any of the seven seas, so that the mines she lays so indiscriminately are hardly likely to sink any of her own vessels.

Minelaying is a job which Germany has to carry out by stealth. The element of surprise is necessary otherwise our mine-sweepers quickly clear away the menace. A fast ship that can easily be disguised has to be used, and even then great care is necessary. Mines have to be designed so that they are safe until they are laid, and provision has to be made to ensure that they stay at the required depth in all kinds of weather.

Hundreds of mines are stored on the deck of a minelayer, and when the vessel reaches the field to be sown, the mines are rolled down the rails in the stern of the craft.

Loaded with a cargo of T.N.T., the minelayer braves torpedoes from lurking U-boats, and chance bombs from enemy planes. No wonder the crew takes such a lively interest in sighting their gun.

The method of laying mines isn't just a simple question of dropping them over the side. The simplest and quickest method of laying is to put down a straight line, as the minelayer keeps on a straight course. But the drawback of this method is that they are just as easy to sweep up. So nowadays the job is done in scientific manner. Before laying operations are commenced the field is plotted out, and some form of zig-zag pattern is employed with patches of clear water left to make things a little more difficult.

German minelaying skill reached a far higher pitch during the last war than did ours. In 1915 submarine minelayers were at work and these small craft laid their "eggs" by releasing batches of twelve through vertical shoots. Later, in 1917, when it became pressingly urgent to close up the Heligoland Bight, the Allies used six minelaying submarines which dropped some 16,000 mines in those waters. The extent to which mines were used between 1914-18 can be realized when it is known that Britain and America laid 172,000 mines in the North Sea and the Channel; mostly in the last eighteen months. Despite the German liking for this type of weapon, they only succeeded in laying about 44,000 in all parts of the world.

Once again the Germans have shown their partiality for surprise tactics. We have seen the magnetic mines improved, and once again laid in an attempt to intimidate neutral shipping; there have been mines dropped in the estuaries of our rivers by parachute; any use in fact, so long as it provides an element of surprise and is well outside the bounds of international undertakings. But this time the element of surprise is not nearly so effective. Our defence methods have been prepared along scientific lines, and counter measures have been ready to be applied.

But for the legitimate purpose of keeping surprise raiders away from our shores mines still provide an effective barrier. Aboard the ships sowing the minefields round our coasts hundreds of the T.N.T. laden "eggs" line the deck, ready to be rolled down the rails into the sea. As they enter the traps in the stern they are held whilst the sinker runs out.

Then splash! And another mine is laid.

The men engaged in this work lose all sense of danger, and take a great pride in their job. Upon them depends whether lurking U-boats can wriggle their way into the lanes of merchant shipping, and all the havoc that a chance pirate can wreak on defenceless ships. So they toil in the dirty weather of the North Sea; intent on making a good job of the intricate pattern of deadly T.N.T. they are sowing beneath the waves.

WAITING THEIR TURN. Stored well below the decks of the minelayer are the dozens of mines that have to be laid to complete the field. The mines are in a harmless condition until they are aboard the ship and it would seem that several of the crew have taken advantage of this situation and inscribed their deadly charges with personal messages for the health and happiness of the Nazis.

READY FOR SOWING. At the rear of the ship are the four minelaying runways. From here the mines are pitched over the side complete with mooring weight and cable. At this juncture the men responsible for the laying of the mines treat the deadly weapons with the utmost respect; it not being one of their ambitions to have any backchat from the explosive monster.

OVER SHE GOES! Over she goes! One more mine is laid in the tremendous chain being used to guard Britain from marauding enemies. There are sighs of relief from the crew as another mine slowly sinks away and is left behind, that's one more "not so secret weapon" that the Germans will have to contend with and about which they won't have any illusions.

twenty-four hours which might have been employed in making the greatest of all scientific discoveries!"

There followed a short silence, during which Professor Maxton waited no further revelations with breathless anticipation.

"Look here, Bell," said Casson at last. "How do you know these things? I'm ready to believe you when you say that this island is the Atlantis of the ancient world. It has reappeared, you say, after thousands of years on the bed of the ocean. Now how can you possibly know . . . ?"

"That's a question I am not prepared to answer just yet," the tall dark man interrupted. "Let it suffice for the moment that I do know what I'm talking about. The greatest secret in the world today is behind those metal doors. You regard this island in precisely the same way as your enemies—as a strategic air-base and the key to the transatlantic air routes. You have all missed the significance of orichalc."

"Do you know just where to find the answers to these secrets?"

"I do! The formula in regard to orichalc is somewhere beneath our very feet—a formula written in hieroglyphics which few living men can read today. Already a man quite capable of reading the ancient picture writing is down there. Professor Maxton is an experienced archæologist, and we must stop him before he discovers too much. Now do you understand why . . . ?"

"Yes, yes!" Casson hastened to say. "Why didn't you explain all this before? What can we do now? The man you mentioned was trapped under the plate on the other side of the island only a few hours ago. When the moon releases him tomorrow night you can be sure Felton-Slingsby and his crowd will be there in force. We're not strong enough to scare them away!"

"Not at the moment," the tall one admitted thoughtfully, "but there's no knowing what the situation will be to-morrow night. If your Zulu pilot carries out his instructions we may be strong enough to make a fight of it and capture Maxton as he crawls out of that hole."

"If Bonilla gets here in time, with the men I have summoned, we shall still be too small a party to make the attack," Casson told him.

"Then we'll make our entrance at this door behind us," the tall one declared. "We must take possession of the underground temple here. Who masters the secrets of that temple is master of the modern world!"

"How do you propose to commercialise the secret of orichalc, Casson?"

The spy hesitated before he answered the question. "It will be a difficult business," he said slowly, "but I shall manage it. It means a trip to Europe for me, but it would be best to confine the offer to the only three powers able to pay my price in real money, and make them fall against each other."

"That won't do for me!" the tall man snarled. "I want the whole world to know what awaits them here."

The sound of voices and feet over rough ground suddenly died away, and a profound silence reigned before Professor Maxton ventured to leave his hiding-place below the glowing plate of orichalc. For a long time he stood there very silent, thinking after all he had heard, and then Maxton began the long journey back to the camp with utmost caution.

Down was breaking over Atlantis when Professor Maxton staggered into the camp near the *British Queen*, and aroused Captain Whitaker and the others.

"I have information of the greatest importance for you," the professor said wearily. "But I must sleep first. Only an hour, Whitaker. Promise me you'll not allow me to sleep an hour!"

After food and stimulants had been provided for Maxton, and he was sleeping soundly, Whitaker roused Slade and Felton-Slingsby to inform them of the professor's strange message.

John Norris came to report that Maxton was sleeping soundly. The geologist was carrying a small bag of tools, and announced his intention to begin a survey of the island.

Whitaker, Verrant, Felton-Slingsby and Slade were present at the conference, and, as usual, they all gathered in the comfortable main cabin of the *British Queen*. Professor Maxton began his story with a solemn warning that startled his audience.

"I want you all to understand," he began impressively, "that while this tall dark man is prowling about at liberty on the island we are all in danger of our lives! Since I was here last I have seen in fact what were mere legends whispered among credulous people. Underneath that metal plate in the rock-bowl is a labyrinth which leads eventually to a temple—a Temple of Evil. Evil lives upon Atlantis—and its servant is the tall dark man.

"Gentlemen, the danger which will confront us when the moon pours her light full upon the orichalc cap of the glass case is such that we would have to abandon this island immediately. We have no weapons with which to destroy such a monster! I am not exaggerating when I tell you that the reptile I saw only a few hours ago is strong enough to wreck a New York skyscraper."

"But it's obvious that you have your doubts about my story, and I can quite understand. All I can do is ask that one or more of you come to the underground temple and see for yourselves."

Felton-Slingsby and Slade spoke together. "I'll come!"

Maxton nodded, and smiled as he turned to Captain Whitaker. "There's just one other point," he added. "From what I overheard of their conversation, Casson and his partner are expecting reinforcements to arrive here within the next few hours. The *Warpath* should be warned."

Whitaker agreed, and went out to find Sammy Deng. Hardly had he got down from the *British Queen*, however, before he heard Jimmy Parrot yelling out a warning from his spy among the rocks. The words were unintelligible, and as Whitaker stood there undecided he saw Sammy Deng running from the new wireless hut in the centre of the camp. Sammy was waving a slip of paper aloft, and pausing to stun the sky as he ran toward Whitaker.

"American plane, *Miami Clipper*, approaching, sir! She's asking for directions."

The *Miami Clipper* made a perfect landing, and hardly was the machine at a standstill before Whitaker and Verrant ran alongside to greet the pilot.

It was a disturbing report to which they listened a few minutes later.

This place in front page news all over the world," the pilot said, "and they're already squabbling over it. I suppose you know that the British and American fleets are patrolling the Atlantic?"

"But where's the danger coming from?" asked Whitaker uneasily.

"There's no real danger yet," the American pilot answered, "but it seems that trouble is on the way here. Our people must be expecting something as soon as the other countries have had time to prepare. It may mean war. Everybody wants to go to Atlantis since the newspapers stated that gold has been found."

"Gold!" echoed Whitaker. "I've heard no word about gold. Who is responsible for that report?"

"The European newspapers had it first. By the way, which of you is Mr. Slade? I have a private letter here for him."

Slade received an envelope heavily sealed, and went away to read a message from the chief of his own department in Washington. When he returned to the crowd surrounding the *Miami Clipper* Slade looked calm enough, and only Felton-Slingsby detected the signs of an inward uneasiness. The British secret service man kept close to Slade while the American plane was relieved of her cargo for Atlantis.

There were arms and ammunition as well as medical supplies and clothing. While the stores were unloaded Whitaker made out a special report for the enlightenment of certain authorities in Washington. It was during this important task that he was interrupted by John Norris.

Norris knocked sharply on the closed door of the main cabin, and did not wait for permission to enter.

"Sorry to burst in on you like this," Norris said hastily, "but what I have to tell can't wait. There's gold on the island, Captain Whitaker. As far as I've been able to discover, a rich reef runs right across Atlantis from south to north and the seam is near the surface."

"Have you mentioned it to anybody else?"

"Not a word," Norris answered. "But somebody knows, because it was through the disturbance they made that I discovered the quartz freshly broken."

Whitaker frowned again as he looked at the gold-bearing rock Norris held out for inspection, and then tore up the report intended for Washington to write out another. His responsibilities on the island were increasing to a point where the task of leadership was beyond him.

When his new report was completed and sealed it was handed to the pilot of the *Miami Clipper*. While the American plane was preparing for her return journey, Whitaker and Verrant discussed the dangers of the situation anxiously.

"We want another plane here," Verrant declared. "Suppose Maxton's story is somewhere near the truth, and we have to clear out of here quickly. There are too many of us to pile into the *British Queen*. Why take unnecessary risks?"

"I quite agree," Whitaker said. "We'll get into touch with the *Warpath*. But I simply can't credit Maxton's tale about that serpent. We have a machine-gun here now which would cut anything living into small pieces."

While this discussion was in progress, Felton-Slingsby and Slade had withdrawn from the camp altogether and were seated on a heap of rocks near the bed of the vanished lake.

"I'm inclined to treat Maxton's story seriously," Slade was saying. "After all, he's one of the world's greatest authorities where ancient things are concerned. They pay him big money in the States for lectures."

"There's only one way to put the matter beyond doubt," Felton-Slingsby replied, "and that's to see this underground temple ourselves. But we must first . . ."

He ceased speaking as the sudden roar of powerful aero-engines reached them.

"The *Miami Clipper*'s off!" he exclaimed, and then resumed the conversation.

"We must first stop Casson and his pal. I think we should pinch the pair of 'em right away, and get Whitaker or Verrant to fly them back prisoners to . . ."

It was at this point that Slade found his attention strangely diverted. He watched the American plane fly out to sea with gathering speed, and what he heard afterwards puzzled him.

"You've not heard a word of what I've been talking about!" exclaimed Felton-Slingsby indignantly. "What's biting you?"

"Listen!" snapped Slade. "The *Miami Clipper* is now well away from us, and yet her engines are growing louder."

They stared at the American plane, now a mere speck in the sky, while the roar of aero-engines became louder. A turn of Felton-Slingsby's head toward the east solved the mystery.

"Look!" he shouted. "This place will be another Croydon soon."

Slade saw them before his companion stopped speaking, and drew a deep breath at the sight of two continental bombing machines flying high toward the interior of the island.

"Casson's plane—and another one to keep it company," Felton-Slingsby growled. "Now we're in trouble, Slade. Better get back to the camp at once."

"Before you go back," Slade said, "there's something you ought to know. I've had a letter from headquarters. In every newspaper throughout the world there is a report of gold found here on Atlantis, and every adventurer the world over wants to have a share of it."

"They can't get here because both the British and American fleets are turning ships away from us. According to my information, Atlantis has become the centre of world interest. The source of the gold report has been traced to Casson."

"It won't be easy to punch him now these two planes have arrived."

"We must find out the danger lurking underground first," Felton-Slingsby urged. "I suggest that we have stores ready beside that metal plate down there, and as soon as it opens tonight we drop them inside and then explore the place with Maxton. We're bound to find Casson and Bell down there somewhere, and may have a chance to settle our account alone."

* * *

Moonlight flooded the great rock-bowl where once had been a lake, and on the bottom a glowing plate of orichalc began slowly to rise from its bed. Four men stood upright and waited expectantly as the plate moved. Three of them carried haversacks packed to capacity and these, when the plate had risen to its full height, were dropped down through the hole one after another while their owners followed.

"All right?" called Verrant from above.

"O.K." said Slade briefly. "So long."

(To be continued next week)

HOW THE ROAD DRILL WORKS

A DIESEL engine drives the two cylinder air compressor, air being stored in reservoirs to which six or seven drills can be connected. Control trigger of drill is raised by gripping handle which compresses air enters, being passed through a cast-iron slide-valve, and forces down the piston which strikes the steel chisel, the air under the piston escaping via the exhaust.

The piston uncovers a passage on the way down and some air is admitted behind the slide-valve. This forces down and also opens a passage at the side, the air then passing under the piston, forcing it up in readiness for the next stroke. This takes place from 300 to 330 times a minute.

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SCIENCE MARCHES ON

WATCH THE SUNSPOTS

This Week's League Tests

Mr. Ralph Stranger, our Director of League Activities, assists you every week in these columns.

THIS new type of aircraft is being built secretly in Oxfordshire. The plane will be a two-seater, high-wing monoplane, and will have a nacelle to accommodate the pilot and passenger instead of a fuselage. The booms, which usually connect the wing and tailplane in an aeroplane of the nacelle type, have been replaced in this design by two wings which will increase the lifting area of the plane, there being in effect three wings. On the normal wing are two 125 h.p. American Menasco "Pirate" air-cooled engines.

THERE are three ways in which an amateur astronomer can observe sunspots. In the first place he can use smoked glass (a candle flame is very effective for this purpose). The smoking should be as uniform as possible. This will enable him to observe the very large spots visible to the naked eye.

One cannot look at the sun through an ordinary telescope as the light would prove to be so blinding as to injure eyesight, and there would be too much heat. For this reason a telescope used for solar observations must have a dark eyepiece which can be obtained from firms specializing in this kind of apparatus.

A perusal of advertisements in the Journal of the British Astronomical Association will help you in this respect.

Talking of the British Astronomical Association, I should like to mention the fact that it is an association of amateur astronomers and everybody who is seriously interested in this work should be a member of this scientific body. I know that members of the Science League will be welcomed.

The third method of observing sunspots is to use an ordinary telescope and project the image of the sun upon a paper screen. The paper may be plain white paper or one can use graph paper for this purpose. The best way is to fix the paper with the help of drawing-pins on a large wooden board.

The telescope must be provided with a fairly stable stand. Having directed the telescope towards the sun, move the screen in line with the telescope, to and fro till a sharp image of the sun is obtained. A little experimenting in this respect will soon show the right way of doing it.

The distance of the screen from the eyepiece will depend upon the telescope you are using, but with the small naval model which I use, I get an image about three feet away.

Such an image will show clearly the sunspots, and it will enable you to study their numbers, their distribution on the surface of the sun, their outlines, and their movement.

It will be necessary for you to alter the position of the telescope as the earth rotates, in other words, as the sun appears to move across the sky.

Daily observations of this kind will show you the variation in the number of sunspots throughout the month, and if you take the trouble to sketch in the sunspots each day, you will have a daily record which will prove to be very instructive.

I should like to hear from all members of the League who have started taking these observations, and I should also like to see the daily or weekly records of sunspots on paper. I shall publish the best effort.

* * *

SEEING THROUGH IT

Is glass transparent?

Well, not perfectly. If it were one hundred per cent transparent it would be quite invisible and we should not know it was there till we touched it. Some of the light rays which strike glass are reflected back from it to our eyes, so that it becomes almost visible.

But there is a way of arranging matters so that glass does become invisible; it is done by absorbing all the reflected rays. The curved shop-windows that are now becoming more frequently met with in the streets of our bigger cities are the most common application of the principle.

The window is constructed in two portions, curved longitudinally and bent to a scientifically calculated line. All light rays are deflected by this curvature upwards and downwards into black velvet, which completely absorbs them, so that the glass is actually invisible and the goods displayed behind it appear to be there for the taking.

So complete is this illusion—and so used are we to *seeing* glass—that the first one installed in London produced a curious and unfortunate result.

It was in the window of the Ford motor showroom in Regent Street. In that showroom, behind the invisible window, a salesman was stationed. A day or two after it had been placed in position he saw a man passing in the street whom he knew. He darted forward to overtake him—and smashed full tilt into the window, breaking it to smithereens and cutting his face severely.

The first one in New York also produced an unexpected sequel. It was the window of a jeweller's and the gold and gems behind it glittered so enticingly and seemed so easy to take that somebody did in fact help himself to them.

The smash-and-grabster was wise to the window, but was overcome by the temptation. He came back with a hammer and chisel, and smashed the glass, getting away with three diamond rings worth £2,000.

Maybe he wouldn't have thought of it if they hadn't seemed to be so easy to take in the first place.

* * *

NEW BOON

"The blessing about wireless is that you can always switch it off."

One sometimes hears that remark from people when the set begins to gush out something they don't like so much as they like something else. When tuneful music gives way to some such deadly "talk" such as "A Day in the Life of an Earwig" they have to rouse themselves, rush across to the set with a groan, and turn knobs.

"Thank goodness you can always switch off!"

But the latest blessing of wireless is that you don't have to.

A gadget has been invented that will automatically fillet talks from programmes while you loll in your easy-chair.

The key to this marvellous boon that will make whole populations grateful is the fact that any speaker has to stop for breath. When the continuous sound, of music, say, emitted by the loudspeaker is broken for a quarter of a second, the gadget switches off for ten seconds, and then on again. If the pause is a pause only in the music, it's all right, and the set remains on. But if it's somebody speaking there is soon another break for breath, and off goes the set once more.

The off-and-on arrangement continues till the device can get continuous sound.

It seems all right, but the snag appears to be that, if a speaker has butted in, the weary listener will have to get up finally to gag him once for all.

It's a hard life! However . . .

* * *

RELAXERCISE

To make life easier another gadget has been invented by which you can get exercise without moving a muscle. You could in fact get the exercise-equivalent of a ten-mile walk while listening to a ten-minute talk on How to Keep Fit, and without as much exertion as it takes to tune in, at that.

The device is the brain-child of Mr. Charles Langberg. He calls it the gymnastic robot, and it's all contained in a little black box no bigger than a portable typewriter. All done by electricity of course.

All you have to do is sit in a chair. The machine does the rest. When the current is switched on, the subject's muscles are electrically massaged in a way that produces all the normal reactions of any type of bodily activity.

If you want some boxing exercise, just "tune in" the knob. In five minutes' lounging you will have the equivalent of twenty rounds of slogging, and not a black eye or a punched nose from first to last. Tune in again, and you can have walking, horse-riding or rowing.

Well, well, science does march on!

* * *

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The snow-plough and how it operates.

THE WONDER OF MICROPHOTOGRAPHY
How you can practice this fascinating science.

LINKING THE EMPIRE
Science joins off corners of the British Empire by means of wireless.

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IS THERE *Life on other PLANETS?*

WALDEMAR KAEMPFFERT presents the evidence both for and against the possibility of there being life on other worlds in the UNIVERSE

WHEN appraising the planets for life, astronomers necessarily go back to the beginning, meaning the creation of the solar system. Three billion years ago, so runs the story, the sun was a lonely, rather second-rate star no different from countless other lonely stars in the universe.

For some another body, a giant, had been creeping into the sun's part of the heavens. Eventually the giant came so near that his powerful attraction raised enormous tides of gas on the sun. The pull grew so strong that huge streamers of gas were drawn out of the sun.

The streamers condensed, much as steam condenses into drops of water. But in this case the drops became nine worlds or planets, twenty-four moons, one thousand two hundred asteroids and one hundred thousand comets—what we call the solar system. The disturber passed on.

Astronomers are not completely reconciled to this hypothesis of the solar system's origin. Yet, whatever its defects may be there is no doubt that the miscellaneous collection of bodies that revolve around the sun were once part of it.

To Sir Arthur Stanley Eddington "the solar system is not a typical product of a star; it is not even a common variety of development; it is a freak." He bases this conclusion on odds of one hundred thousand to one against our finding in the universe a sun of the right type surrounded by planets.

According to him not one in a hundred million stars could have undergone the experience of meeting another star in space and of losing some of its matter by gravitational attraction as the sun did. If the solar system is a freak, then the strangest of all freaks is life.

The largest telescopes reveal about a thousand million stars. Are these centres of planetary systems like that of the sun? And are their infinitesimal, invisible planets inhabited? At least one star in three is a double, and mathematical physicists cannot conceive of any celestial mechanism which would make it possible for nine planets to revolve around two suns.

Of the remaining luminaries a large number are variable stars, which flare up and die alternately and make life, dependent on steady radiation of celestial energy, impossible. Eddington's odds are none too large.

To be alive is evidently an exciting cosmic adventure. For life is chemically and physically precarious. Tilt the axis of a world so that it assumes a new angle to the ecliptic, lengthen or shorten the day materially, rob the atmosphere of its oxygen and water vapour, change the mass of a world and therefore its gravitational attraction or considerably increase or decrease the distance of that mass from the sun and every living creature perishes.

A combination of a dozen known essentials and perhaps many more that are not known made it possible for the first bit of protoplasmic ooze to become animate, to reproduce itself.

Why is Mars red? Because it is rusty, according to a plausible speculation of Professor Henry Norris Russell's. The yellow of Sahara's sands, the redness of the Painted Desert's rocks, the brick colour of the ocean's bottom—all are caused by oxidation, or rusting. So with Mars.

Most of the oxygen of Mars has been chemically captured. If there are Martians they have learned to drive off the oxygen from rocks and clays or else, in the course of their Darwinian evolution, they have adapted themselves to the kind of atmosphere they now have. No terrestrial man could live on Mars without a tank of oxygen and a helmet.

It is the water vapour on Mars of which the physicists are sure. They see it not only in the atmosphere, but in caps on the poles—caps which melt away as summer comes and which grow again in winter.

But there is very little water. Professor Edward Charles Pickering calculated that if twenty feet of snow fell over a Martian polar area an ocean of 2,000 miles diameter, but only two feet deep, would be formed in one of our months during the melting season.

As the caps melt russet brown areas in the temperate and equatorial zones gradually turn green. Here is evidence of irrigation, argued Percival Lowell. If intelligent beings dwelt on Mars they would sink all their hatreds in a co-operative effort to irrigate the deserts with melting polar snow. To Schiaparelli's "canals" Lowell saw the necessary ditches.

This romantic interpretation of the seasonal Martian aspect was never accepted by astronomers. On the other hand, they are no longer so ready to deny that when the russet brown areas turn green we may actually behold the growth of vegetation.

"Tuft-forming grasses such as grow on high prairies, like the tussock grasses of Peru and Patagonia, and especially the mosses and lichens which grow in Arctic regions," surmises Dr. William Weber Coblentz, who made one of the most thorough studies of the planet on record. But higher Martian life? No reputable astronomer believes in it.

The big planets, Jupiter (diameter 88,700 miles), Saturn (75,100 miles), Uranus (30,900 miles) and Neptune (33,000 miles) are so similar that they can be considered together. Their distance from the sun varies from 483,000,000 miles for Jupiter to 2,790,000,000 miles for Neptune. Cold so bitter that it can freeze air prevails on all their surfaces.

According to the new knowledge, the cores of all these planets consist of rock and metal. Around the cores are thick shells of ice that form frozen oceans thousands of miles deep. Above the oceans are atmospheres of ammonia, methane (marsh gas), hydrogen, helium.

If there is rain on these big planets it is not rain of water. On Jupiter, with a minimum temperature of 187 degrees Fahrenheit below zero, it is a rain of ammonia. On Saturn so much of the ammonia has poured down that the methane in the atmosphere is more conspicuous.

On more distant Uranus and Neptune nearly all the ammonia has been precipitated in blizzards so that it presumably encrusts the surface in the form of frozen oceans. No life is conceivable on the big planets.

(Condensed from "New York Times Magazine")

An artist's conception of the landscape on the surface of a lifeless planet. (Inset) a photo-diagram of Mars showing the lake of the sun and the canals. It is thought that plant life lives on the planet.

DID YOU EVER WONDER?

FIRE AND ICE WON'T BREAK GLASS

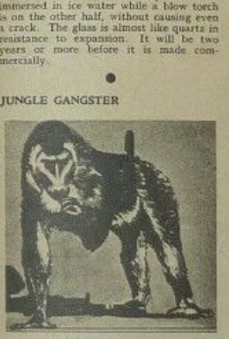
A new kind of glass which shrinks by one-third in size after it has been formed into dishes or other utensils has been developed in America. The shrinkage is done by heating and results in a glass that is virtually immune to cracking from sudden changes of extreme heat or cold.

This new glass is made of the same materials used to cast the 200-inch "eye" of the world's greatest telescope a few months ago. The difference is mainly in the "cooking." The raw materials are melted and fashioned into utensils, then cooled. This glass is soaked for hours in diluted nitric acid.

The acid dissolves out of the glass about 30 per cent of its silica. Remaining is a piece of glass hard as a frozen sponge, and filled with fine holes where the silica has been dissolved. It is next heated almost to melting. The whole mass thereupon contracts into a clear, solid piece of glass.

A glass plate 12½ inches across shrinks to nine inches. One-half the plate can be immersed in ice water while a blow torch is on the other half, without causing even a crack. The glass is almost like quartz in resistance to expansion. It will be two years or more before it is made commercially.

JUNGLE GANGSTER



The mandrill is a native of the West Coast of Africa, and is savage and treacherous. It is reputed to have attempted the kidnapping of women and children in Guinea. Walks on all fours, using one hand to feed itself. A taste for alcohol is unusually manifest in this creature; although its normal diet is fruit, it will savagely kill any bird or small mammal captured.

ARE ASTRONOMICAL MEASUREMENTS ACCURATE?

Most people incline to regard as quite accurate the scientific measurements of heat, gravitation, pressure, and equilibrium in stars and other astronomical bodies. Actually, however, the measurements of distant bodies by the most careful and painstaking scientists are far from accurate.

They are, in fact, largely a matter of guesswork. Thermometers are not, of course, employed in attempting to determine the heat of astronomical bodies, and there is no mechanical way of finding out much about heat that is hundreds of thousands of miles distant.

Theories come and go regarding the heat of the sun and stars. It was believed at one time that the sun was being consumed like so much coal; were this the case, however, the sun would have lasted no more than 7,000 years.

During the last century a group of scientists formulated the theory according to which the sun squeezes energy out of itself when the interior matter attracts the exterior; this theory, however, fails to explain the long-time heat of the sun.

Within the last twenty years astrophysicists have turned to atomic energy to account for the heat and light of the stars.

Because the sun is 93,000,000 miles distant from the earth, and because there is a distance of 430,000 miles from the sun's surface to its interior, even the most painstaking scientists must make arbitrary assumptions about the heat at the sun's centre.

Because of the vast distances involved, estimates of the sun's internal heat vary from billions to millions of degrees. Arbitrary assumptions must be made also in regard to the pressure, gravitation, radiation, states of equilibrium and a dozen other aspects of distant heavenly bodies.

THE DUTCH OF SOUTH AFRICA OFTEN BAKE THEIR BREAD IN ANTHILLS! THE HUGE MOUNDS LEFT BY THE BIG RED ANTS OF THE COUNTRY ARE SCOOPED OUT ON THE INSIDE, AND THE HOLE BLOCKED BY A PIECE OF IRON TO MAKE A USABLE OVEN!

BLOOMS ONLY AT NIGHT

Epiphyllum latifrons is the botanical name for the night-flowering cactus. This beautiful lilylike flower appears only at night, and a most remarkable feature is that it blooms only when there is a full moon.

Although cacti are not really natives of Asia, this night-flowering variety flourishes throughout the Malayan Peninsula.

The buds may be seen forming for a couple of weeks or more before the period of the full moon, and when it appears the beautiful flowers come out in all their glory. No flower was ever so sweetly scented. One bloom in the house will throw its aroma throughout every room.

The bloom is, however, short lived, for with the dawn the flowers fade. There will be no more for at least another month.

Phosphorus ignites when exposed to air, but all the same some of its compounds are used to fireproof textile fabrics and wood. Apart from this, phosphorus is also essential to life, adults needing about twenty grains daily, whilst children require thirty grains every twenty-four hours.

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K72 H68

I BUILT A SUBMARINE

by William S. BOYCE

THIS model is simple in design; all working parts being external, any adjustment can therefore be made immediately and without difficulty.

The hull is cut from a piece of 2½ in. by ¾ in. American whitewood or pine, length about 20 in. From this cut a 16½ in. length for the hull and shape as illustrated. The remainder is for the conning tower, cut to the dimensions given and shaped with a rasp.

Next saw a fourteen inch length from a broom handle, saw this in two from end to end, taking care that the two halves are equal, these are then placed together again, clamped in a vice and shaped at each end with a spoke-shave. One half is for the starboard ballast tank and the other for the port. These should be nailed in position with wire nails along top and bottom.

Conning tower and deck fittings should be fitted last so as not to damage them while working.

The hydroplanes or fins are next cut to size and after marking off one inch from the nose of the ballast tanks, drill a hole to take a two inch length of 3/32 in. brass or copper tubing, through which a 3½ in. length of brass wire is taken, leaving ½ in. protruding each side. After making sure that the tube is parallel to the deck and that the wire fits tight in the tube, solder the hydroplanes in position.

The particulars and dimensions given for the mechanism must be taken as approximate. The gears, for instance, in the writer's model are gears of an old alarm clock, the ratio being about four to one.

The main support for the bearings is the shaft of an old clock key, the handle of which has been removed and a screw of suitable size with the head cut off soldered in position (as illustrated). The original shafts are removed from the gears and replaced by suitable lengths cut from a wire coat hanger and soldered in position. The position of the gears should then be ascertained and the holes drilled in the main support to take the new shafts mentioned. The propeller and lower shaft should be about 1½ in. in length and bear the small pinion gear. The screw shaft support is screwed in position which is to compensate the rather slender main support. This screw should lightly rest on the main shaft (which is about 2 in. in length) and when the mechanism is completed may be screwed or unscrewed according to the upward or downward tension of the elastic.

The dimensions of the wire supporting stays must be left to your own requirements. For the upper stay a hole is drilled in the stern (see illustration) and the stay passed through and bent down on each side to meet the lower stay and then soldered in position.

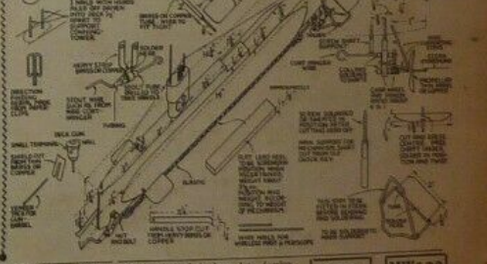
The winding gear must also be left to your own requirements. In the model illustrated a Meccano coupling was improvised for the winding bearing. The handle was shaped from a cutting of the wire coat hanger previously mentioned. The handle stop is of heavy brass or copper and is screwed to one side of the hub. This is to prevent the return of the handle after winding.

Weight and position of the keel is governed by forward and aft weight of the mechanism. To arrive at this, complete all fittings with the exception of the wireless aerial (which is fitted last) and hold the keel temporarily in position with elastic bands round the hull. Try the submarine in water, and after finding the correct position, nail or screw the keel underneath the hull.

The wireless aerial may now be fitted and the hull and all other fittings except the wireless aerials and driving gears painted grey, with class letter and number white.

The motive power is twelve strands of elastic (quarter inch), which should be lubricated occasionally with soft soap.

Give about one hundred and fifty turns of the elastic for the first trial, and if you wish the submarine to submerge, elevate the fore hydroplanes about twenty degrees, and the aft lowered fifteen degrees. Give a slight push forward and downward when starting the run. The submarine will rise to the surface again when the elastic has lost a little of its power and continues on the surface. For a surface run, keep the hydroplanes fore and aft parallel with the deck.



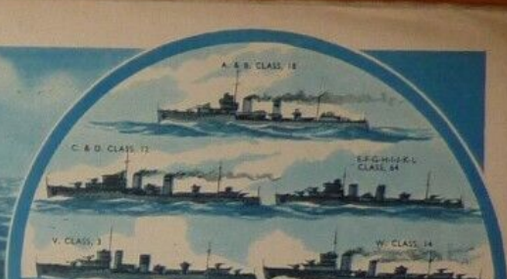
F94 MW120

IN DEFENCE OF BRITAIN

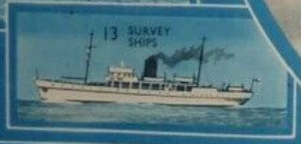
The BRITISH ROYAL NAVY

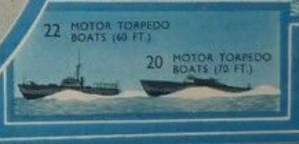
The Royal Navy must remain Britain's first line of defence and on these pages is arrayed a picture of every class of British warship with its corresponding number. This mighty fleet will in all number some 620 fighting ships and 104 auxiliaries.

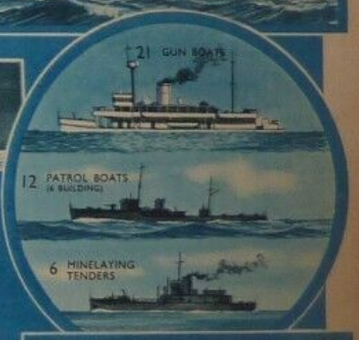
36 FLOTILLA LEADERS

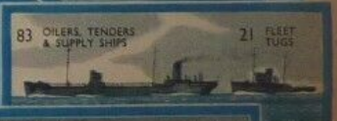


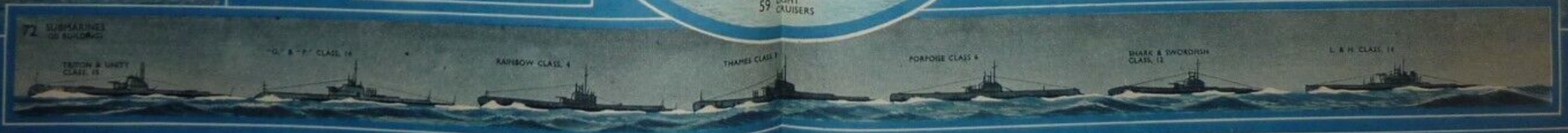
157 DESTROYERS (24 BUILDING)

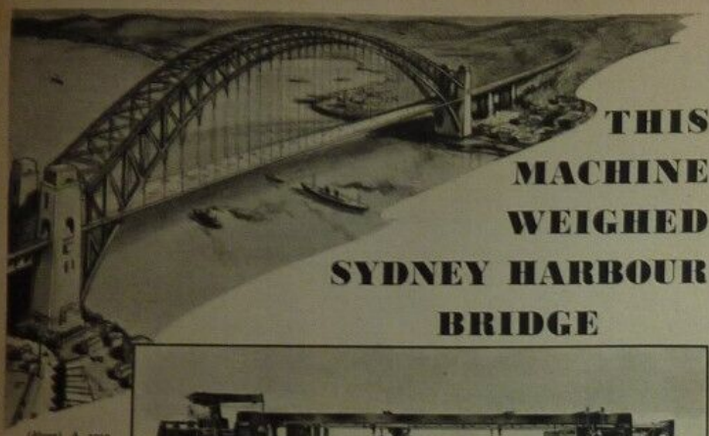












THIS MACHINE WEIGHED SYDNEY HARBOUR BRIDGE

(Above) A span of the mighty Sydney Bridge and, right, the wonder scale on which fifty-foot sections of the bridge were weighed.

By **Lewis E. D. ESSEX**

I SUPPOSE it is fairly common knowledge today that of all classes of crime, the forging of cheques and other documents of value is one of the most common.

It is common because, in the hands of expert criminals, it is comparatively easy of accomplishment. And conversely, and most unfortunately for the law-abiding community, forgery of this kind is extremely difficult of detection.

Until recently, Scotland Yard has probably had to write "insolved" against this class of offence more frequently than any other. I say "until recently," because an extremely valuable device is now at their service, the employment of which should go far to make the lot of the forger extremely more uncomfortable and hazardous than it has been in the past.

It is now possible to weigh your signature on your bank cheque!

Let me explain, first of all, that it has been discovered that the "weight" of your signature remains a fairly constant factor. Naturally, it you happened to pass more heavily than usual on pen or pencil, the resulting writing would be heavier than usual.

But it so happens that the signing of a cheque or document is usually one of the most automatic and spontaneous things we do. It follows, therefore, that the amount of ink or graphite expended on that effort, like the amount of energy, is about the same.

Now, if we could weigh the amount of ink or graphite suspected as being forged, it would be found to differ in weight very considerably from the genuine signature.

Absurd, you say. Impossible. How on earth could you weigh a few strokes of writing, fast and dry upon paper?

Well, a few years ago your indignant criticism would have been justified. And had any author used such an idea you might have turned the book down in disgust. Them doesn't exist a balance fine enough," you would have said, "to be capable of registering such split hair differences."

But there it have just been taken into a room in Birmingham where such balances are tested. And tested not only to a degree of accuracy to register the weight of a signature, for they will register the weight of your initials only!

And before I describe these balances, it's even more interesting to describe the room in which they are housed.

Imagine a room, utterly vibrationless. Not easy, seeing that the earth, from crust to centre, is in a constant state of vibration and tremors.

But here in the Avery factory at Birmingham, laid upon virgin soil is a massive floor eighteen inches in thickness. Directly "linked" to the floor are walls of solid concrete, and now, over all, are laid two inches of special cork insulating material. This cork insulation, to use an Irishism, is to isolate the vibration which isn't there.

Dead in the centre of this room rests a solid block of concrete, two feet square. When I first saw it I thought I was on an execution "set" in Hollywood or Denham, but it wasn't anything gory like that.

To avoid the possibility of sunlight playing upon the beams and so affecting the delicate accuracy of these superfine balances while under test, all direct daylight is excluded from the room. Further, in order to nullify the least variation of temperature, the room is steam and electrically heated, thermostatically controlled to ensure absolutely invariable thermometer registration.

Now as to the balance itself. Without going into minute technical details, it is of all appearance similar to the finest balances used by scientists and research analysts. It presents an appearance of spidery delicacy. Bearings are all made of the highest quality agate, of extreme hardness, and each component is tested over and over again for alignment, size, and so on.

When it is explained that maximum capacity of the balance is no more than ten grains, a slight idea of the delicacy of workmanship may be gathered. But only slight. Until it is realised that the sensitiveness of this balance is such that it is capable of registering error to *less than one thousandth part of a grain*, the miracle of its construction will remain unappreciated.

And then will be understood the why and wherefore of those concrete walls.

So now the "load" of a signature on a cheque can be weighed as faithfully as a pound of sugar by your grocer. Already the thousandth of a grain balance has proved invaluable to bankers, to detectives and others in the detection and prevention of crime, to say nothing of countless uses in the realms of science, medicine and physics.

That is one miracle in the way of testing a "load." But here is another of a very different order. Indeed, right at the other end of the "scales."

It is an historical fact that Stephenson, the famous engineer, just prior to the construction of the tubular bridge across Menai Straits, built a model bridge, loading it with weights till it collapsed.

Then he repaired and strengthened the model over and over again, increasing the dead weight till it fractured afresh. Until finally he increased the carrying capacity of his model by more than ninety per cent. And that's how the bridge was built.

A reliable but supremely wasteful and costly method, but, astonishing to record, a practice followed until modern times, when the system of weighing and testing loads and stresses in bridge building was revolutionised by the construction of the Avery "Universal" machine.

This machine, the largest in the world, has a loading capacity of no less than 1,250 tons at the same time! Think of it in relation to one thousandth part of a grain!

But for this huge machine, it is safe to say that the amazing speed with which the Sydney Harbour Bridge was built, to say nothing of the even more remarkable accuracy achieved, would never have been possible.

For whole members of the bridge, no less than fifty feet in length, were accommodated, weighed, stressed and tested to the enormous load just stated.

There is a machine which, by the setting of a scale and the revolution of a drum at a desired speed, produces the exact blend of tea, say Indian and China, that is required. And the funny thing is that large numbers of these machines go to India and China. Very much a case of carrying coals back to Newcastle.

There is a weighing machine for eggs. And very much of a machine, too, seeing that at a touch of a lever the products of Mrs. White-Wyandotte or Madame Black Minorca are graded "special," "standard," or "pullet." And at the no mean speed of 2,250 eggs per hour.

And not one in the odd two and a quarter thousand ever gets cracked, either! I wonder what farm hand or dairy maid could be relied upon to sort eggs like that!

While James Watt, the greatest inventor of his age, and the man who gave us the steam engine, was working in the Birmingham foundry in 1768, a man, shabby and ill-kempt, came in one day and asked for a job. The foreman turned him away and the man dropped his hat. Watt looked up, for the hat made a funny sound in falling. The man, in answer to questions told Watt he had *made his hat from wood*, and that he had discovered a way of *turning an oval object on a lathe*.

At once he was given a job, at the princely salary of 25s. a week. But this man was William Murdock, the discoverer of lighting *by* coal gas! The oldest gas-holder in the world, identical with the very latest working today, is still to be seen in this Birmingham foundry.

British inventive genius has shed light in other and far wider directions. For here was built and sent to the Argentine the largest livestock scale ever made. It is built as a complete shed, the floor being the scales and when it is said that one hundred head of cattle can be weighed at a time on the enormous scale, no elaboration of its strength and capacity is required.

THE COOLING TOWER

This abnormal looking tower can be seen anywhere near a big power station.

Hot water from the condensers of the steam turbines used for generating electricity passes up the central pipe in the tower and is distributed to the water troughs. Here it is cooled quickly and passes down over splash cups to the numerous splash boards where it is further cooled and finally drops to the well in bottom of the tower. This cooled water is very suitable for use in the boilers again and is therefore pumped back to them.

We shall soon be able to see the friend with whom we talk over the telephone.

The co-axial cable used on the London-Birmingham system. Frequencies varying in wave-length from 150 to 2,000 metres can be transmitted.

The TELEVISION-TELEPHONE IS COMING

by William SYDNEY

CREEPING its way underground from London to Newcastle-on-Tyne is a strange new kind of cable that is going to alter the whole system of telephone communication and to carry television into every part of the country.

Early next year millions of people will be using this cable to talk by telephone without realizing its great significance. Hundreds of people will be talking to each other over the same line—and yet no conversation will interfere with another.

Later on television will follow. They will be able to see each other as they talk, and television programmes will be relayed from one centre to another.

Compare this new cable with the one that it used at present and you will see how the Post Office engineers have evolved it.

The ordinary telephone "line" consists of two wires wound round each other and known as a "pair." From every telephone whether it is in a house or an office a "pair" runs directly to the telephone exchange. The exchanges are connected with each other by hundreds of "pairs."

Now supposing you want to make a call from London to Birmingham. You lift up your receiver, or, if you are on an automatic exchange, you dial the operator, the result is the same. She establishes contact with you by joining her "pair" to yours in the same way as you close an electric circuit by joining two wires.

When you have booked your call, she calls up the Birmingham exchange in the same way as you have just called her, and the Birmingham exchange calls up the person you want.

Now the important thing to remember about this is that you are occupying a "pair" of wires to yourself from your telephone to that of the person to whom you are talking in Birmingham. The wire from your mouthpiece is joined to his earphone, via your exchange and the Birmingham exchange. The wire at your earphone is joined to his mouthpiece, so that you talk down one wire and listen down the other.

No one else can have that "pair" of wires until you have finished, and when all the "pairs" between two cities or towns are engaged, you are told that "all lines are engaged." Between such centres as, say, London and Dublin or Manchester and Dublin, there is often an hour's delay before a line is free.

So far, so good. But there is a complication, and a costly one too.

It is obviously impossible for the voice vibrations to travel unaided all the way along the line from London to Birmingham. A small stream, travelling along its bed without any other water coming in to reinforce it, would slowly die away through infiltration into the earth.

So with the voice vibrations. Every forty miles or so along the line, is a "repeater" station in which the vibrations are built up again with an ordinary amplifier as in a wireless loud speaker. The costly part of this is that, since every conversation requires its own special "pair" of wires, each "pair" of wires requires its own "repeater" station.

There seemed no way out of this difficulty until the Post Office engineers developed the new cable, a picture of which you see. The principle is that instead of having the wires wound round each other, one is inside the other in the way you see. They do not touch, but their axes are the same. That is why it is now called the co-axial cable.

Along this cable it is possible to transmit frequencies varying in wave-length from one hundred and fifty metres to two thousand metres. In other words, by varying at will the wave-length of any conversation, the Post Office engineers found they could transmit many conversations along the same cable. They could, if they wished to do so, relay all the programmes of all the wireless stations operating between one hundred and fifty metres and two thousand metres without those programmes interrupting each other any more than they do in the ether.

To apply this principle to telephone conversations is simple, although not without great initial expense. Four of the lines are laid underground in one great cable. Amplifiers have to be laid at frequent intervals, every six or seven miles. But, and here the actual saving is great, one amplifier will serve the whole cable. At each end, complicated terminal apparatus is installed to turn the sound of the human voice into minute speech currents at frequencies of millions of cycles a second for transmission over the line.

In this way it is now possible for three hundred and twenty different conversations to be carried over one line without any interfering with the other.

Only two of these cables are to be used for the telephone next year. The other two are to be laid down for television.

There are two methods of television for the public. One is to keep only the studios in London and relay the programmes over these cables to be re-broadcast at various centres, such as Birmingham, Manchester, Leeds and Newcastle-on-Tyne, where the cable will lead to eventually.

The other way is to set up studios in each of these studios so that programmes can be relayed from one to the other.

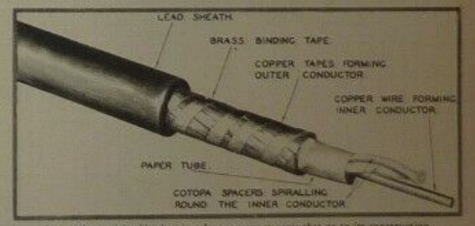
Another service which is being considered is that of the telephone-television by which you can talk to a person over the telephone and see him at the same time.

In this case, the principle is exactly the same as in broadcasting where the programme, both visual and oral, is relayed over land line from the studio to the transmitting station.

The Germans have succeeded in developing this service to an amazing extent, although they admit that it is purely for spectacular purposes and does not pay commercially. Television-telephone communication is available between Berlin and Leipzig, and in one experiment, it has been carried out over a distance of three hundred miles.

It is quite impossible now to do it in this country. It is, however, too costly at present because, whereas three hundred and twenty telephone conversations can be carried on one line, one television relay will take up the whole of one line.

Nevertheless, as soon as this cable is laid—and so far it has reached Manchester, more than half its journey—television will be an accomplished fact for the areas around the cable, and everything will be ready for the British Broadcasting Corporation to put it into operation.



A typical co-axial cable showing the component parts that go to its construction.

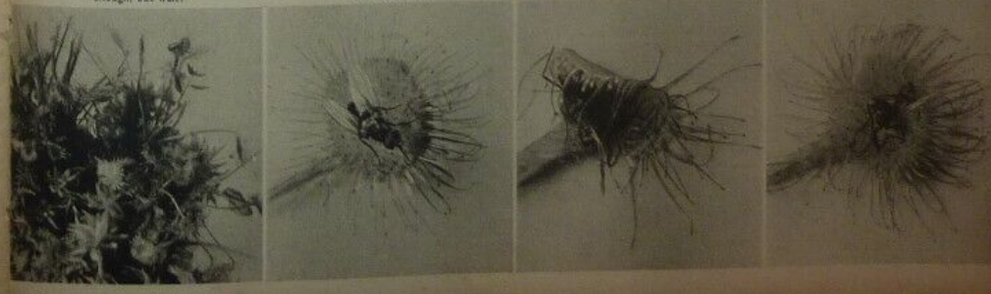
THIS CANNIBAL FLOWER EATS INSECTS

Here is the sun-dew with its sticky pans looking like flowers. It appears harmless enough, but wait!

A fly or ant, mistaking the sticky secretion for honey, settles on the flower and finds itself caught fast.

Escape is impossible and despite the struggles of the insect, the leaves fold over it remorselessly and life is soon extinct.

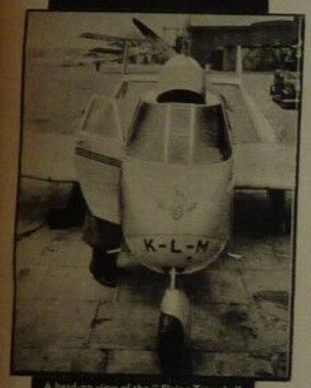
The end of the tragedy. Having sucked out the digestible parts, the leaf opens and sheds itself of the remains of the insect.



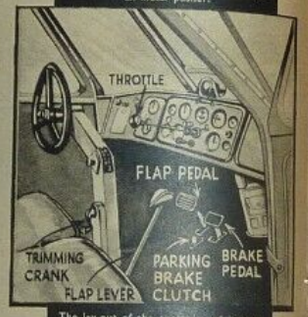
TRICYCLES of the SKIES

The Stearman-Hammond in flight.

Notable features of the machine are the tricycle type of undercarriage which provides foolproof landings, and the all-metal pusher.

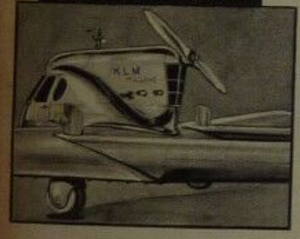


A head-on view of the "Flying Tricycle" showing the exterior of the side-by-side cabin. Below is seen the cowled Menasco engine and the structure on the roof that carries the venturi and pitot head.



The lay-out of the controls and instruments in the side-by-side cabin. The wheeled control column is of the swing-over type and the throttle, which is of the plunger type, is placed in the centre of the dash and can thus be reached with equal ease from both seats.

(Reproduced by courtesy of "Flight")



The nose-wheel, windscreen and air scoop. The machine has a span of 40 ft., a length of 26 ft. 11 ins., and a height of 7 ft. 7 ins.

ONCE upon a time, around 1900, when aircraft were beginning to become a practical proposition, nearly every one of them had a three- or four-wheeled undercarriage.

Failing this they had a skid in front of the wheels. The object of this in those days was to make an ordinary landing easier. Man was not so skilled with his wings, knew less about them, than he does now.

Those early aircraft were built with no idea of streamlining. They were covered with struts and wires. So an extra bit of "drag" didn't matter.

Later, in the war days, clean design began to mean something. The front wheels, wheel or skids were not vitally necessary and had to go. Aeroplanes began to be a little more difficult to land, but people became used to it.

This state of affairs has gone on until the present day. Nobody denied that a wheel in front made landing easier, but people could land machines in the normal way anyhow, and the extra wheel took too much speed off.

Suddenly, however, in the past few months, the three-wheeled undercarriage has returned. What is the reason for this reversion?

The answer can be divided into two parts—comfort and safety. America was the originator of the new three-wheeler. Over there they use sleeper air liners a great deal more than we do. When a sleeper lands at night and draws to rest with its tail down and its nose up in the air it is uncomfortable for the people in the bunks. They tend to slide out.

The aircraft designers decided to do something about this. They found that the obvious solution was a nose wheel, so that the machine rested on an even keel when it was on the ground.

In this case the extra wheel presented no more drag than two wheels, as they all tucked away neatly into the wings and fuselage when the liner was in flight.

The extra wheel made it necessary for the pilots to learn a new landing technique. They had to forget all about pulling the nose right up and stalling the ship at the last moment. And, in turn, the pilots found that landing on three wheels was not only easier but safer than landing on two. So everyone was happy.

Now nearly all the new air liners being designed are to be three-wheelers.

But, in addition to the big machines there is a spate of small tricycles coming out, both for private use and for training. In Britain we have the Monospar and the Cowey-Eagster three-wheeler. The latter is to be adapted to the Fleet Air Arm, so that deck landings shall be simpler.

America has the new Waco, the Gwinn Aircar, the Stearman-Hammond, and several others. They all serve one purpose—easier flying for the private owner. Modern engines and modern streamlining take away several of the disadvantages of the unattractive third wheel.

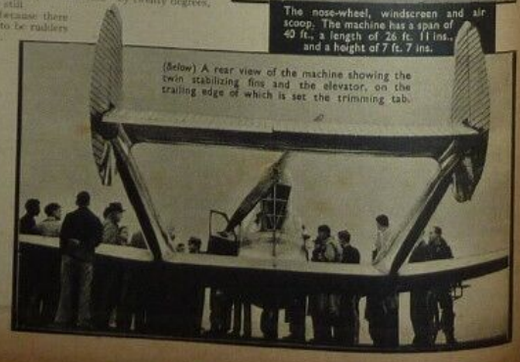
The Stearman-Hammond is illustrated on this page. It was brought to Europe to train the Royal Dutch Airline pilots in three-wheeled technique, as all their new ships are to be big tricycles.

It is an all-metal two seater, with a Menasco 150 h.p. supercharged motor at the back of the cabin. The air screw revolves between the two metal booms that hold the tail.

The pilot and passenger sit right in the nose, in an all-enclosed draught-proof cabin. There is no engine cowling to spoil their view. The interior of the cabin is practically the same as that of a two-seater car. All the controls are orthodox, except that there is no rudder control.

On the floor there are two pedals. One of these is a foot brake, exactly the same as a car foot brake. The other is a flap pedal. When this is pressed, it increases the angle of the flaps—air brakes—by twenty degrees, so that landing is made easier still.

There is no rudder control because there are no rudders. What appear to be rudders are stabilizing fins for the tail.



(Below) A rear view of the machine showing the twin stabilizing fins and the elevator, on the trailing edge of which is set the trimming tab.

They have an turning movement to left or right. The machine is turned on its ailerons by turning the wheel on top of the control column to left or right. It looks like a car steering wheel.

The Stearman is climbed or dived by moving the column forwards or backwards.

One of the wheels is situated in the nose, the other two under the wings in the same line as the booms holding the tail.

On the ground these fit close to the fuselage, in the air they hang down about two feet. This is the shock-absorbing gear. When the machines land these retracting legs take the shock and move up into cylinders at the top of their travel. In this way the machine is made strong enough to be dropped for about seven feet without breaking.

The third wheel enables the machine to be flown straight at the ground. There is no complicated process of holding off until it has lost all flying speed. In addition, once it is on the ground it stays put. The third wheel stops it from nosing over if it lands too fast, or is pulled up too suddenly. It behaves just like a motor car on the ground, can be taxied as fast as the pilot likes without any chance of it scraping a wing or "ground-looping."

So far, the Stearman is expensive. It would cost about £2,000 over here. In America it is much cheaper. Customs duty forms the extra cost. But the machine will probably be manufactured here for about £1,000.

It should cut about two hours off the normal flying tuition time, enabling you to learn to fly and get your licence in ten hours.

Capt. F. Kingdon-Ward, the explorer and botanist, whose journeyings in search of plants are long and arduous undertakings fraught with danger.

DARING DEATH FOR A FLOWER

By **Carl OLSSON**

I CAN still remember the bitter, disgusted expression on the face of a young nephew of mine when he told me that he had "to do botany next term."

"Botany!" he moaned, "girls' stuff . . . picking flowers . . . ugh!" So I told him something which is pretty much upon the lines of this story.

At this moment, somewhere along the headwaters of the Yuan-Kiang or Red River, there is a man picking flowers. His name is Captain F. Kingdon-Ward. *He* is a botanist—a plant hunter.

If you will look at a good atlas, you will see that the Yuan-Kiang runs through a country called Yunnan which lies to the east of Northern Burma and to the south of Tibet. The route which Kingdon-Ward set out to traverse last January, crosses snow-bound, unknown peaks rising over fourteen thousand feet. It is a desolate country visited by no white men before.

There are great and lonely hazards to be encountered, mountain blizzards like those which sweep down the Himalayas, the unfriendliness of natives who dwell in those remote fastnesses, guides and porters who may abandon the traveller, sickness and the danger of wild beasts.

Nobody knows yet, even, whether Kingdon-Ward is still alive. There are no pillar-boxes among those strange mountain passes into which to drop a letter; no runners to carry a message to the coast, or to the nearest British post a thousand miles away. We shall hear nothing of him till he comes out—a year after he went in.

"Girls' stuff"? Yet Kingdon-Ward is a flower-picker, a botanist. So are other great plant hunters of whom you have possibly never heard, like George Forrest of Edinburgh, Dr. Chipp of Kew Gardens, Captain Burslett, Major Kingston, Darlington of the John Innes Institute at Merton.

YEAR after year these men depart on lonely and unheralded expeditions into jungles, mountains and the unknown places of the earth. Not for mapping, shooting, treasure-hunting or the motives that inspire the better-known explorers. But to find a new plant, a new species.

To come out safely after perils and arduous journeyings with a few handfuls of seed, a bag of dried bulbs or roots or, even, a single specimen of something new—that is the aim and object of the plant-hunters.

Sometimes, like Kingdon-Ward, they are explorers and mappers, too. On all his expeditions he takes theodolites, levels and other surveyors' equipment with him. And on some of his fourteen journeys in Tibet, North-West China, and other remote parts of Asia, he has put over one hundred thousand square miles of unknown territory, mountains and rivers on to our maps. He holds the highest awards of the Royal Geographical Society for his work in this direction.

Will those few seeds, bulbs or roots of a new or different plant be worth a trip of thousands of miles and all the dangers and risks in seeking it?

With some of the plant-hunters it is pure science first and all the time. They are sent out by some museum, botanical gardens or university which wishes to add a new species to its collection, or hopes to obtain variants of a certain species for study. And these employers foot the bill of the expedition.

With others it is often a mixture of pure science and commercial considerations. A new plant is worth hundreds, and often thousands of pounds to wealthy private gardeners—people like Mr. Lionel de Rothschild and the Hon. Mrs. Maclaren who have unexampled botanical collections.

They collect rare plants in the same spirit that other connoisseurs collect "old masters," first editions, rare stamps, and often at the same cost. The plant-hunter goes to such people for part of the finance for his expeditions, they buy his "finds" when he comes back.

Further backing is obtained from great firms of manufacturing chemists who are always in the market for new herbs or plants which might yield medicinal drugs. The plant-hunter's own botanical knowledge helps him on such quests, but he is always alert to notice what plants the natives in little-known regions use for their medicines and poisons.

This source of income is largely dying out now that so many drugs, formerly extracted from plants, are made synthetically in the laboratories. But a market still exists for new deposits of rare medicinal plants which has so far resisted synthesis.

A plant-hunter, for example, who could find large new sources of *hydrastis* root and who could arrange for its collection and delivery to any of the big drug houses or brokers would make a fortune for life. *Hydrastis*, from which a potent tonic is made, is found only in one or two places on the earth's surface (North America, chiefly) and these are sparse yields.

But the chief backer of the plant-hunters is the seed and flower industry.

The total value of just one branch of it—the cut flower trade—in this country is now over £15,000,000. You can add another £5,000,000 for the bulbs, roots, plants and seeds which are bought for gardening. That is a surprising total. It is more than half of the money spent at the cinema box-offices and represents about six shillings and fourpence a year per head of the population.

It makes this little country the greatest flower buying and gardening nation in the world. And it is the plant-hunters from Hooke and Darwin (yes, he was a plant-hunter, too) to men like Kingdon-Ward and Forrest who have made it so.

Look at any list of the favourite cut flowers — irises, carnations, dahlias, chrysanthemums, or the gardener's favourites — rhododendron, magnolia, phlox, calceolaria and *hundreds* more, and you will not find one that is native to this country.

The plant-hunters have brought them in. And they have searched for and found exotic varieties of established flowers so that the seedsmen, mating and hybridizing with the old and the new varieties, have produced even more wonderful blooms, more exquisite colourings, longer-lived flowers.

A few years ago, Kingdon-Ward, when hunting some windswept slope of the Himalayas, came across a *dianthus*—a carnation—growing in a sheltered spot. It was of a miraculous blue colour. Its seeds which he brought home were worth two hundred pounds an ounce.

The seed firm which acquired the monopoly have spent years of delicate, careful work matching and mating that first precious batch with other varieties. In another year or two you may be able to buy a sixpenny packet of carnation seeds of a certain name and colour. In the germ cells of each seed will be a trace of that parent bloom packed by Kingdon-Ward in the far off Himalayas.

Narcissi, lupins, blue poppies are common enough blooms today; but the ever-new beauties and colourings in which you buy them are due to the plant-hunter's efforts who, perhaps at the risk of his life, first collected the new variety. He is well paid, which, of course, is as it should be. There is a new narcissus called S.17, which at present is worth two hundred and fifty pounds a bulb. But you may soon buy it for sixpence.

In some flower shops today you can buy an orchid bloom like the *cymbidium*, or the "butterfly orchid" for as little as one shilling. The parents of those blooms were originally called by a plant-hunter in some fever-haunted swamp of the Amazon jungle.

He braved murderous tribes and deadly reptiles and insects to find them and to get back to the coast with a few bulbs that looked like dried up onions. Those bulbs were worth five hundred pounds each. And now you can buy one of the blooms for a shilling.

There are specialists among the plant-hunters. Several hunt exclusively for orchids. A profitable field, too. For a new orchid fetches a fabulous sum today. One of the last discovered, of the Sophronites variety (if you can manage the name it is Lælio-Cattleya-Cocottæ) would, if the present owner deigned to sell, fetch several thousands of pounds. It blooms once in ten years.

Captain Kingdon-Ward's speciality is alpine or mountain plants. He has possibly made a good deal of money out of those he has brought back from places like the Andes, the Burmese Highlands and the Himalayas, but there is not a suburban rockery in Britain which does not owe something to his work in this direction.

Another hunter I have mentioned, Capt. Burslett, concentrated on rarities. He would often pass by a plant, no matter how valuable if it had been collected before. One of his last finds, a plant called *Vanda Sanderiana*, sold for five thousand dollars (one thousand pounds) a time in the American market.

The next time you hear any of the time-honoured jeers about botany being girls' stuff, remember the great industry built upon this science, remember the multitude of tiny gardens it has brought into being and the beauty and happiness that flowers bring to the lives of millions.

And remember the plant-hunters battling their way through jungles and across remote mountain ranges to add to the treasures of that science.

"Flower pickers"—"Girls' stuff"! No! "He-man's" stuff.

In the heart of the tropic jungle grow plants that may bring wealth to their discoverer and health to his fellow-men.

FRANCE'S ARMÉE DE L'AIR

THE MIGHTY FRENCH AERIAL FIGHTING MACHINE THAT WILL COMBINE WITH THE ROYAL AIR FORCE TO MAKE AN AIR SERVICE INVINCIBLE TO ANY ENEMY

FORMULATED at about the same time as Britain's original aerial fighting services, France's Air Force can be compared with any in Europe. It is one of the most efficient war machines in the world, and when combined with the R.A.F., as it will be in the present hostilities, it will help to make a fighting service that is invincible not only by its quantity but, above all, its quality.

The Armée de l'Air is under the administration of the French Air Ministry and is controlled by the Supreme Air Council of which the Air Minister is the President. The rest of the council is made up of an Inspector-General, the Chief of Air Staff, and five other general officers.

Before the commencement of the war it was estimated that France had well over 2,500 first line aircraft, with about 1,000 in reserve.

Perhaps more important than the actual number of aircraft at present in service, France has built up a "behind the lines" system of aircraft production that will enable her to replace and increase the strength of her first line continuously.

This rapid system of production that is now in operation all over France has an estimated monthly output that is equal to any other nation in the world. The immediate change from a peace-time basis to a war-time basis in all factories enabled this system to go into operation instantaneously, and it was a matter of days before the large-scale production of military planes was resulting in a never-ending stream issuing from factories all over the country.

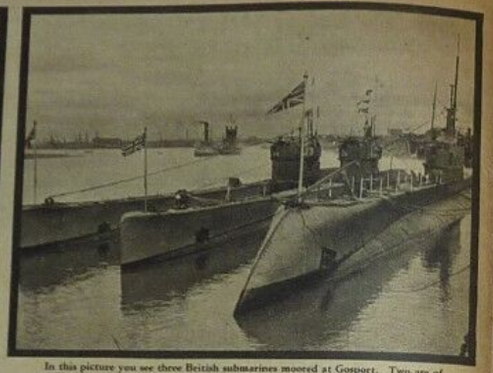
Additionally, the estimate of the French Armée de l'Air personnel before the outbreak of hostilities was in the region of 40,000. It is beyond a doubt that this has now vastly increased and that a very large section of the mobilized manhood of the French nation is now incorporated in the Armée de l'Air.

Co-operation between the British and French nations has resulted in the virtual amalgamation of their two Air Forces.

In quality of equipment, efficiency of personnel and quantity both of first line machines and rate of production, they have presented to the enemy a fighting machine which is not only at the present moment an undefeatable block, but has behind it the skill and careful co-operation of years of experienced knowledge with the spirit of comradeship in a common cause.

B.S.M.

Preparing a torpedo on board a submarine for practice firing. A cork head is used instead of explosive so that the practice shot does not damage the target vessel. As each torpedo costs over £2,000, they are recovered after firing.



In this picture you see three British submarines moored at Gosport. Two are of different type from the other one, and guns can be seen mounted on the conning towers.

UNDERWATER

THE SUBMARINE WAS FIRST INVENTED IN 1620

There are three possible ways of diving with a submarine. In this illustration the after hydroplane is turned down to dive.

Diving can also be done in the vertical position without the engines running.

Another method combines vertical diving with forward movement. Hydroplanes are turned upwards.

ONE of the newest and most deadly branches in modern navies is that of the undersea craft. The element of surprise is an important factor in all warfare, and nothing could be more suited for providing it on the sea than the modern submarine.

Although of comparative recent development, the idea of ships that could travel under the sea is centuries old. There have been legends dating as far back as Alexander the Great which have told of amazing vessels which could dive beneath the surface of the sea, and bob up again to the confusion of their enemies.

But it was not until 1620, when King James I was on the throne of England, that a Dutchman, van Drebel by name, built the first vessel to travel under water.

Surprising as it may seem the demonstration of this first submarine were very successful. The tests were made on the Thames and the ship was able to remain under water for several hours at a depth of from twelve to fifteen feet. True the method of propelling it was not very satisfactory, and for this reason it seems surprising that the demonstration was possible at all.

Twelve rowers had to sweat and toil to take this submergible boat from Westminster to Greenwich, but it is said that the king himself risked a journey in this new type of vessel.

After the success of this first experiment other designers got to work, but it was not until the year 1776 that a submarine craft was built and used for the purpose of war. Throughout the many years during which inventors taxed their brains to perfect an undersea craft the great stumbling block was always to find a satisfactory means of propulsion.

FIRST SUBMARINE ATTACK

The first submarine war craft was American. It was built by David Bushnell, and his method of getting over the necessity for rowers was to fit a hand-turned screw. The use to which it was put was to carry out an elaborately planned attack on a British warship which was moored off the harbour of New York.

The submarine carried a charge of gunpowder which it was planned should be attached to the keel of the warship, and then exploded. The scheme failed, but the idea had been born and in 1864, during the American Civil War, a blockading warship was sunk by a torpedo discharged from the bow of a submarine.

Encouraged by the success of these early experiments the Americans continued to work on the development of undersea craft, and other nations including France became interested in this new kind of war vessel which could steal upon its enemy unawares. To France, in fact, goes the distinction of being the first European nation to add submarines to their navy.

The first of these craft which they built was named the *Gymnote*; was a thirty-ton vessel, and driven by an electric motor. At its trials French naval architects were greatly encouraged by the satisfactory performance, and a few years later decided to go a step further and build a two hundred and seventy ton craft.

BRITAIN STARTS TO BUILD

Its performance surprised everybody, and by the year 1900 the navies started to sit up and take notice of the new craft that was to play a big part in future warfare.

America was still a leading builder of this kind of ship, and the first five submarines ordered by the British naval authorities were made from the plans of an American designer. In the first instance these vessels were ordered so that the naval authorities could experiment with means to overcome their deadly use by enemies, but in the years preceding the World War we find that this country improved on submarine design, producing larger and larger craft.

When the World War broke out in 1914 submarines had yet to be really tried out. At that time they were to a great degree an unknown quantity, and very few of the nations had any number at the commencement. Britain had some thirty-six of various types, but of these many were only suitable for harbour defence work, and the others could put to sea only for quite short times.

Germany had rather less, about twenty-eight, but only ten of these were sea-going craft, and nobody was quite certain how effective they would prove in actual warfare. Certainly both sides found a use for submarines for patrol work, but other jobs which had been planned for them in peace time proved impracticable under war conditions.

The Gallipoli campaign provided the allied submarines with their biggest test, and in the naval operations carried out at that time they proved of very definite value as a new method of offensive warfare on the sea.

The attempt by German submarines to blockade the coasts of Britain and prevent food from entering the country proved that the submarine was a dangerous new weapon which could be used against the civilian population of any country. The craft that interested James I in 1620 had developed into a fearsome war machine which was liable to starve the women and children of any warring countries.

Modern submarines, one of the most formidable types in present day warships, are really submergible boats. As surface craft they are capable of a great range, and as they only submerge to escape from an enemy or to attack, this kind of vessel is very suitable for sinking up and delivering a death blow before its foe knows of its presence.

Just how these submergible boats manage to challenge the laws of gravity, and make themselves either sufficiently light to float on the surface of the water, or else heavy enough to sink to a predetermined depth under it, is one of the modern wonders of scientific development.

The hull of the vessel is shaped for maximum buoyancy and has the graceful lines which produce a streamline effect to the resistance of the water. The tanks which fill with sea-water so that buoyancy can be neutralized, can also be emptied by compressed air when the hull returns to the surface. But it is the hydroplanes, horizontal rudders, that drive the ship below the surface, steer it whilst there, and bring it once again to a floating position.

DIVING BENEATH THE WAVES

From the conning tower of the submarine stretches the periscope, the eye of the crew as they travel beneath the surface. To a depth of thirty feet they can use it to steer their course, or as a range-finder for the torpedo tubes, but as soon as they go below this depth the craft becomes blind and navigation is done by instruments.

Armaments on the modern submarine are still principally torpedoes. Around 1800 an American inventor combined with the submarine the use of a crude kind of torpedo, and since those early days this kind of weapon has been further developed and made the chief method of attack with under-sea craft. But as the submarine has developed its armaments have improved. One of the latest experimental types is fitted with four 5.2 inch guns, and most of the modern craft have small guns up to 4-inch.

Recent craft are very different in size and speed to those used even at the close of the World War. One of the latest has a submerged displacement of 3,600 tons, and is capable of a speed of nineteen and a half knots on the surface. An even larger boat is the French submarine *Surcouf*, which with a higher tonnage mounts two 8-inch guns, in addition to fourteen torpedo tubes.

Below decks the crew live in rather confined quarters, but when it is remembered that all the machinery and munitions have to be carried in the hull it is surprising that room can be found for them at all. Diesel engines designed to give six thousand horsepower propel the modern submarine on the surface, but because they would use up too much of the available air an alternative electric motive power is provided when the vessel is submerged.

This is the motor room which houses the Diesel engine, which is used when the craft is on the surface. When submerged the machinery is switched off and electric motors fed by batteries propel the craft through the water.

Sleeping quarters for nearly all the forty members of the crew are provided, and bunks are fitted up in all kinds of odd corners throughout the craft to provide rest for the men.

With the periscope only partly raised the captain takes a quick look at the approaching enemy. As soon as he has seen all that is necessary, the periscope will be lowered.

It is mealtime in a modern submarine and we find the men seated at a table which has been fixed up in the space made possible by raising some of the sleeping bunks.

WARSHIPS

By Bernard HOGBEN

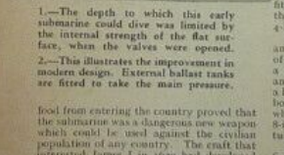
Although going down in submarines is not attended with the hazards experienced by the pioneers, safety precautions have to be provided so that the crew of the vessel can escape to the surface should the craft meet with disaster.

Modern escape apparatus is fitted on all British submarines and all the men who serve on these ships are made familiar with the safety device which will supply them with sufficient oxygen to arrive safely on the surface.

One very important new development in the evolution of the submarine comes from Germany, and is likely, if successful, to prove that undersea craft can tackle their foes as easily by sense of hearing as sight.

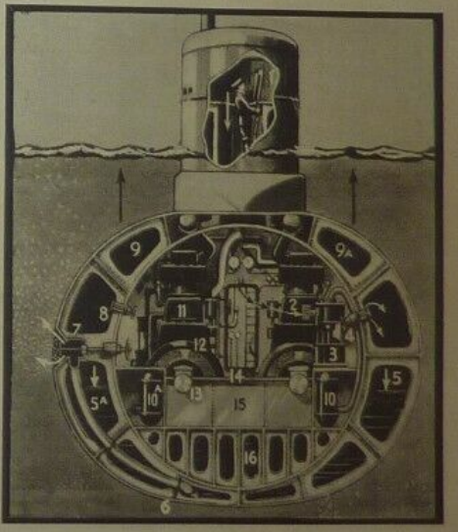
The hydrophone, the listening apparatus invented during the World War so as to detect the presence of submarines which cost Germany many of her craft, is believed to be a new scientific aid which will enable the submergible boat to dispense with its periscope. The tip of the submarine's "eye" cutting through the water betrays its presence to a watchful foe, so that any means for overcoming surface projections of this kind are bound to make the submarine even more formidable than it is today.

The weakness of the electrical undersea listening device was that it was so sensitive it picked up every sound, but modern experiments have devised means for making the apparatus capable of selecting sounds which will aid its use as an automatic pilot.



1.—The depth to which this early submarine could dive was limited by the internal strength of the flat surface, when the valves were opened.

2.—This illustrates the improvement in modern design. External ballast tanks are fitted to take the main pressure.



This sketch shows how a modern submarine returns to the surface: 1, Submarine breaking surface, with conning tower hatch open to admit outside air; 2, Air inlet; 3, Air pump forcing air into tanks; 4, Three-way blowing valve; 5, 5a, Air forcing water out of external ballast tanks; 6, Water pipe; 7, Flooding valve open for ejecting water; 8, Air vent valve to relieve pressure; 9, 9a, Special anti-rolling tanks; 10, 10a, Compressed air bottles, used for blowing tanks; 11, Diesel engines; 12, Main electric motors; 13, Propeller shafts; 14, Watertight door; 15, Battery tank; 16, Internal ballast tanks for maintaining positive buoyancy.

BRITAIN'S PREMIER AIRPORT CROYDON

AIRCRAFT
The De Havilland "Frobisher" class. Top speed, 234 m.p.h.; 32 seats; 2,100 h.p. on four engines. Operates from Croydon with the A.W. "Ensign" over most of the European routes.

High voltage discharge tubes containing neon gas act as an identification beacon for pilots. It is visible for a great distance and penetrates fog and cloud.

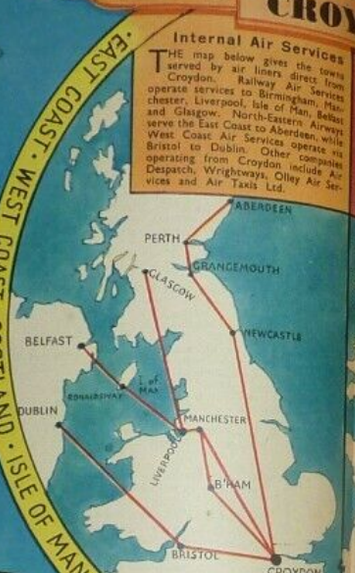
D.H. "Dragon Rapide." Extensively used on many internal air routes. Speed, 157 m.p.h.; seats, 10. Above machine owned by Wrightways Ltd., who operate freight service to Paris.

D.H. "86 B." Ten passenger, 166 m.p.h. air liner used by Railway Air Services, North-Eastern Airways, etc.

Handley Page "42." A veteran type used by Imperial Airways for many years and now being gradually replaced by modern machines. Still operates Le Touquet service and others.

Internal Air Services

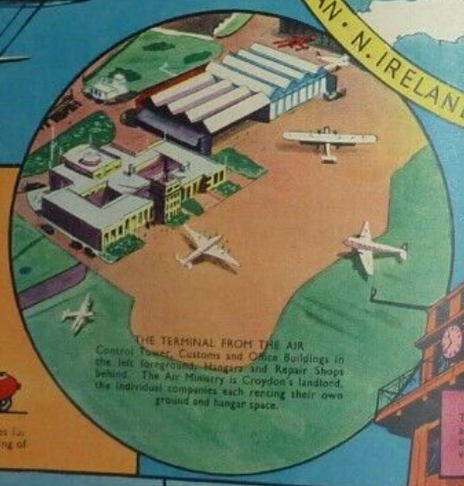
THE map below gives the towns served by air liners direct from Croydon. Railway Air Services operate services to Birmingham, Manchester, Liverpool, Isle of Man, Belfast and Glasgow. North-Eastern Airways serve the East Coast to Aberdeen, while West Coast Air Services operate via Bristol to Dublin. Other companies operating from Croydon include Air Despatch, Wrightways, Olley Air Services and Air Taxis Ltd.



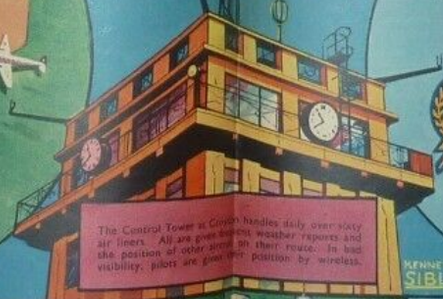
Continental Services

ALMOST every town of importance can be reached from Croydon by air. The map below gives some idea of the principal services, many of them direct routes. The most important companies operating from the airport include Imperial Airways, Air France, the Deutsche Lufthansa, A.G., the K.L.M. (Dutch Air Lines), Swissair, S.A.B.E.N.A. (Belgian Air Lines), the Swedish Aerotransport Co., the Danish D.D.L., and the Avio Linee Italiane S.A.

EAST COAST · WEST COAST · SCOTLAND · ISLE OF MAN · N. IRELAND · EIRE ETC. · FRANCE · GERMANY · HOLLAND · BELGIUM · SWITZERLAND · SCANDINAVIA · ITALY · ETC.



THE TERMINAL FROM THE AIR
Control Tower, Customs and Office Buildings in the left foreground. Hangars and Repair Shops behind. The Air Ministry is Croydon's landlord, the individual companies each renting their own ground and hanger space.



The Control Tower at Croydon handles daily over sixty air liners. All are given frequent weather reports and the position of other aircraft on their route. In bad visibility, pilots are given their position by wireless.

Uniforms and badges of Imperial Airways: 1, Commander; 2, First Officer; 3, Radio Officer; 4, Pilot's Wings; 5, Radio Officer's Badge; 6, Uniform of Commander (nose rank worn on shoulder straps only); 7, Cap Badge, all officers.

KENNETH M. SIBLEY

Marcel Bloch "220" type; used by Air France. Top speed, 213 m.p.h.; to pass engers; two engines of 890 h.p. each. Operate an hourly service to Paris.

Junkers "J.U. 52/3 m." Used by German Airways (D.L.H.), Belgian Air Lines and British Airways. Cruising speed, 160 m.p.h.; 16 passengers.

Beacons such as this are in position at selected points along the route to Croydon in order that pilots may check their position. The light beam is thrown out at an angle.

Douglas "D.C.3." American built air liner used by K.L.M., Swissair, Swedish Air Lines, etc. Top speed, 212 m.p.h.; 21 passengers.

Savoia-Marchetti "S.73." Italian type used by the Belgian Air Lines. Speed, 200 m.p.h.; 18 passengers; three engines, 600 h.p. each.

Passengers en route for the Continent travel from London to Croydon by fast motor coach (left). Each company has its own colouring; the one shown belongs to Imperial Airways.

Refuelling Tenders. The big oil and petrol companies contract with the air lines for refuelling services and oil supplies. Two types are shown, the right-hand one being of more modern design.

Air mail plays an important part in Croydon's busy life. Special Post Office Air Mail vans of streamlined design transport the mail direct to the planes waiting on the tarmac. Over 40,000,000 letters are carried from Croydon annually.

The Air Ministry own the fire and ambulance appliances, one of each being stationed in readiness at the airport.

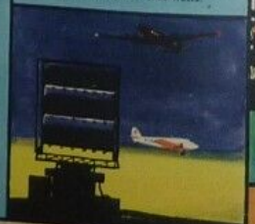
Tractors are used for turning the huge aircraft out of the hangars and on to the tarmac. They are of varying design each company supplying its own type.

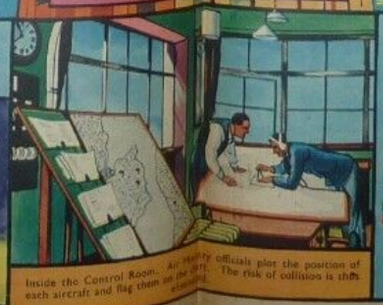
This Wind Indicator consists of a T-shaped framework balanced at its centre of gravity and free to rotate. The action of the wind on the fin keeps the T pointing into the wind. The arms are 20 feet long and illuminated at night.

How to distinguish the international markings of aircraft operating from the airport.

D—AAAA to D—ZZZZ—Germany
EI—AAA to EI—ZZZ—Eire
F—AAAA to F—ZZZZ—France
G—AAAA to G—ZZZZ—Great Britain
HB followed by numbers—Switzerland
I—AAAA to I—ZZZZ—Italy
OO—AAA to OO—ZZZ—Belgium
OY—AAA to OY—ZZZ—Denmark
PH—AAA to PH—ZZZ—Holland
SE—AAA to SE—ZZZ—Sweden

The landing floodlights in use at Croydon are built in three tiers mounted on a framework. Each tier contains two tubular lamps of 1,000 watts.

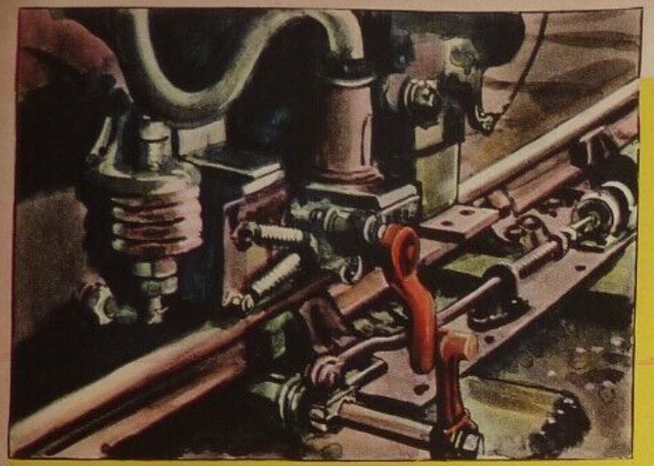




Inside the Control Room. Air Traffic officials plot the position of each aircraft and flag them on the [illegible]. The risk of collision is thus [illegible]

Most of the Air lines operating from Croydon have a house, or distinguishing sign which they fly when on the ground. They are not flown when the aircraft is in flight. All British companies fly the Civil Ensign with a special company marking on the machine. 1, British Civil Air Ensign; 1A, Imperial Airways (design on nose). 2, Air France; 2A, Design on side of Air France aircraft. 3, German Air Lines (D.L.H.); 3A, Tail marking of all German aircraft. 4, K.L.M. Royal Dutch Air Lines; 4A, Marking on nose. 5, Railway Air Services (on fin); 5A, R.A.S. machines carry stripes on fuselage. 6, Tail marking for all Swiss aircraft; 6A, Marking on nose, Swiss Air Lines. 7, Belgian Air Lines (S.A.B.E.N.A.). 8, Swedish Air Lines. 9, Danish D.D.L. 10, Avio Linee Italiane, S.A.

SAFETY PRECAUTIONS ON TUBE RAILWAYS

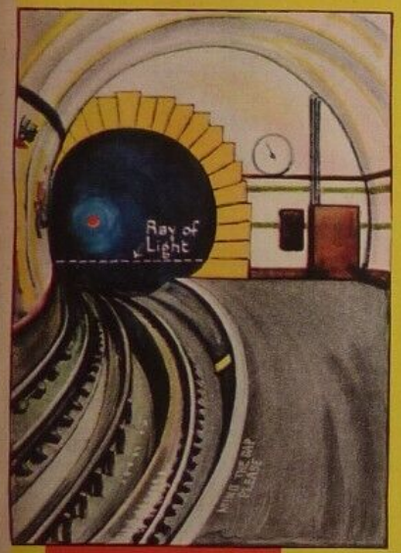


The Stop Arm seen above functions when a driver inadvertently passes a red signal. Operated by the same mechanism that controls the signal, the stop arm (shown in red) strikes a finger known as a trip that projects below the body of the motor coach. When this happens, the trip is moved upwards, automatically cutting off the current and applying the brake, and it is impossible for the train to proceed until the trip has been reset by the driver.

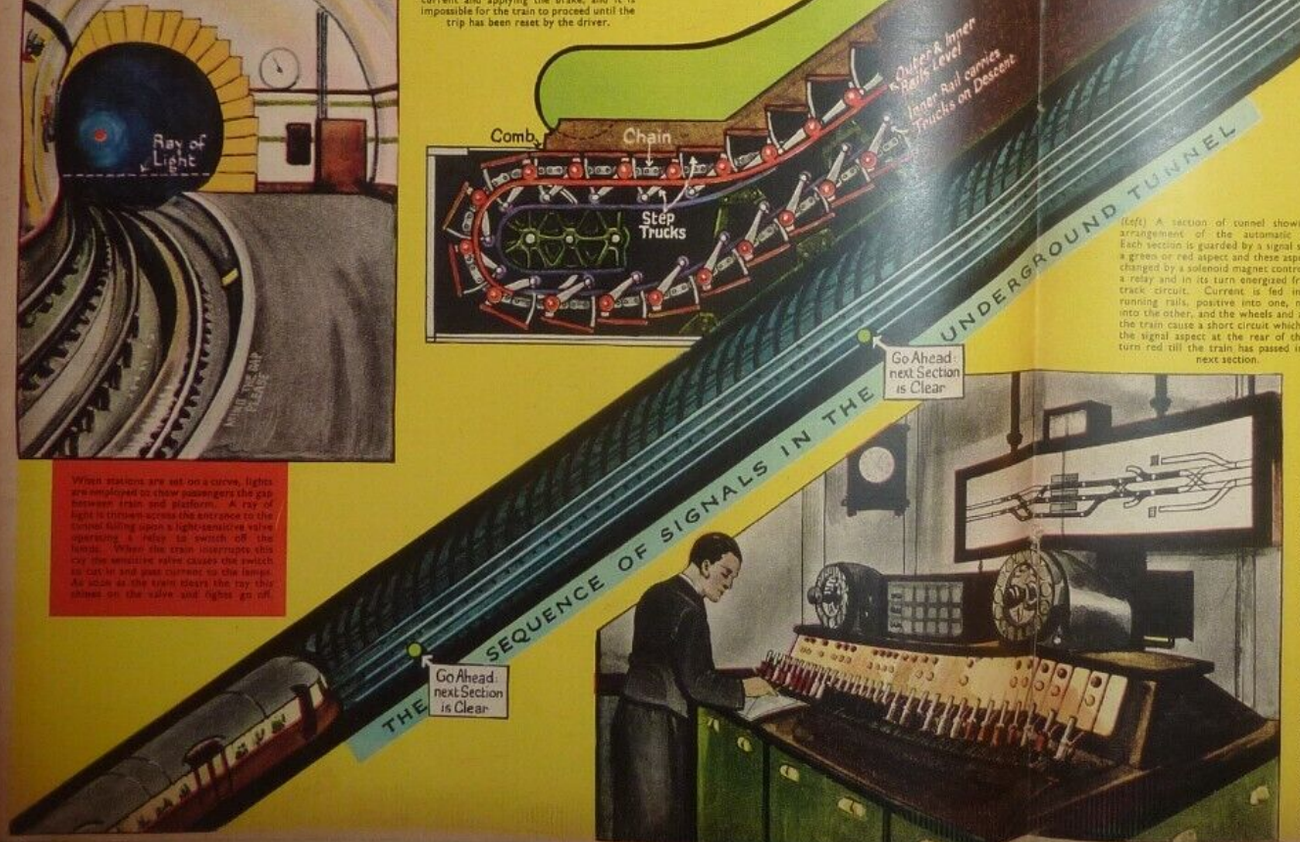
(Left) The Dead Man's Handle is so called because the driver keeps it pressed down all the time the train is running, only releasing it in a case of sudden illness or collapse. When pressure is released from this hinged control handle, the current is immediately cut off and the train's brakes applied, bringing the train to a stop.

The Escalator, or moving stairway, a sectional view of which is shown below, is found in many stations. Each step is a four-wheeled truck, the wheels being set out of line with each other and running on two separate pairs of rails. All are linked together by a heavy roller chain passing over a sprocket driven by an electric motor.

The relative level of successive step treads is governed by the difference between the levels of the rails, and when all steps are level as at the top and bottom of the escalator the inner rails are lower than the outer ones but parallel to them. The step trucks are tilted at an angle of 30° and when travelling downwards do so upside down. The driving motor which has anything up to 150 h.p. gives a maximum speed of 180 feet a minute.



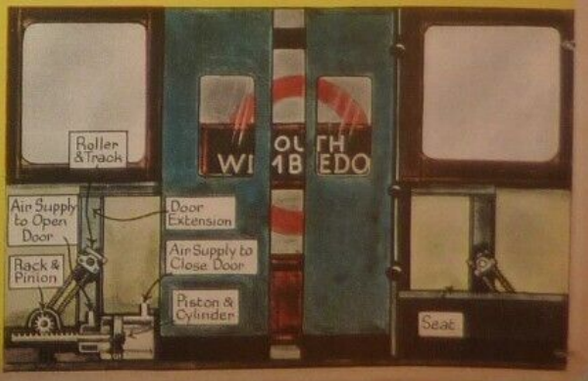
When stations are set on a curve, lights are employed to show passengers the gap between train and platform. A ray of light is thrown across the entrance to the tunnel failing upon a light-sensitive valve operating a relay to switch off the lamps. When the train interrupts this ray the sensitive valve causes the switch to cut in and pass current to the lamps. As soon as the train clears the ray the lamps on the valve and lights go off.



(Left) A section of tunnel showing the arrangement of the automatic signals. Each section is guarded by a signal showing a green or red aspect and these aspects are changed by a solenoid magnet controlled by a relay and in its turn energized from the track circuit. Current is fed into the running rails, positive into one, negative into the other, and the wheels and axles of the train cause a short circuit which makes the signal aspect at the rear of the train turn red till the train has passed into the next section.

(Left) Signal Cabin equipped with the Illuminated Diagram, a glass panel with a map of the tracks controlled from the box and illuminated from behind. A black patch denotes the position of trains on the section covered. All points on the Underground are power-operated and the levers in the signal box are merely switches that set in motion the operating current and are so interlocked that a wrong route cannot be set up.

(Right) The engines for operating the self-opening doors are set below the seat immediately next to the door. A piston driven by compressed air has a rack cut on its rod and this turns a pinion to which is fastened an arm that pulls the door open, with a roller-bearing head running in a groove formed on the door extension frame. It is controlled by the guard and low-pressure air from the brake reservoir cylinder is used.



(Right) In the event of a breakdown, the driver can establish communication immediately with the engineers. By hooking the two leads of his portable telephone to the two bare copper wires that run through every tunnel, the driver is at once in touch with the nearest sub-station. If it is necessary to cut off the current he does so by pinching the two wires together.

Driver and guard can speak together over the telephones installed in the train. On the guard's control panel is a mouthpiece and push-button, below which is a grille screening a small loudspeaker reproducing the driver's voice. A similar outfit is installed in the driver's cabin.

The WONDER of FLIGHT

AERODYNAMICS is the science which deals with the mysteries of flight or the reaction of a body in motion relative to the air. There is no need to get frightened by such a word, for on these pages our artists have endeavoured to deal with it in a manner every one can understand. If any one wants to study the subject further they will find themselves involved in a crowd of mathematics. Man has learnt many lessons from the birds and a study of their flight is very interesting.

Let us first take a consideration of the force which air can exert and it is enough to say that it is very great. Indeed it is because of this fact that the aeroplanes are able to fly. To understand this it is necessary to realise that the force which air can exert is the same, for a given speed, whether you are still and the wind is blowing past you, or whether the air is still and you are moving rapidly through it.

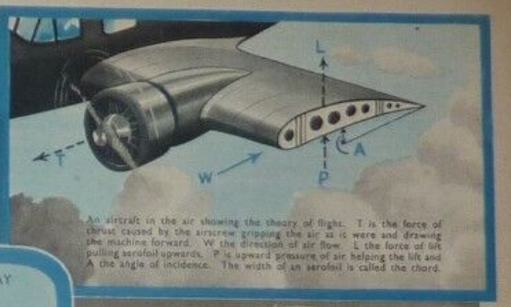
Now the modern aeroplane wing or aerofoil, as it is called, is so designed that the utmost advantage is taken of the air flow over its surfaces to give it lift and here again it is practically the same shape as a bird's wing.

The development of the petrol engine provided the aeroplane with its means of moving forward through the air and the two forces combined, that is, lift and thrust, enables the aeroplane to fly. This, of course, is putting it very simply.

THE MECHANISM OF LIFT

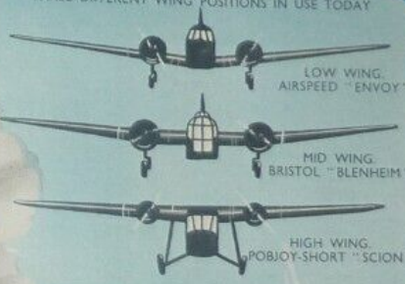
A wing section or aerofoil placed in a flow of air will produce several interesting results. In front of the aerofoil the air is giving up and gaining speed: on top, this produces lift. Underneath the wing the air is going slower.

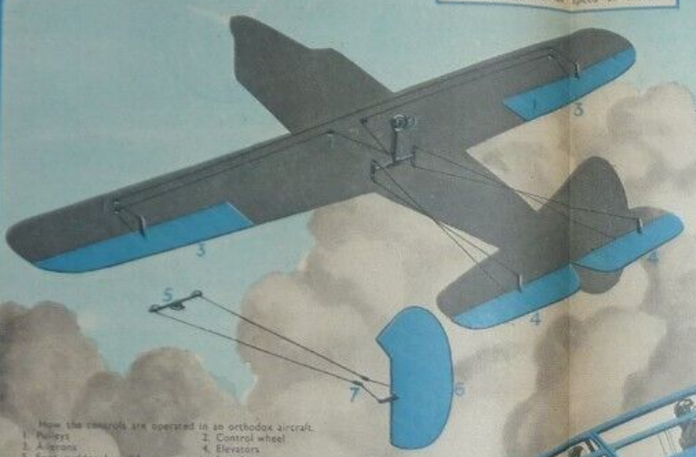
The downward and backward movement of a gull's wings, and also all other birds, gives them their flying power. Downward for lift and backward for speed or thrust.



An aircraft in the air showing the theory of flight. T is the force of thrust caused by the airscrew gripping the air as it were and drawing the machine forward. W the direction of air flow. L the force of lift pulling aerofoil upwards. P is upward pressure of air helping the lift and A the angle of incidence. The width of an aerofoil is called the chord.

THREE DIFFERENT WING POSITIONS IN USE TODAY

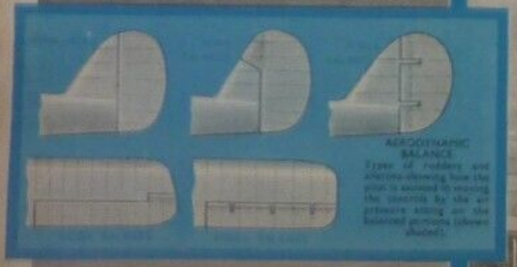




How the controls are operated in an orthodox aircraft.
1. Pulleys
2. Control wheel
3. Aileron
4. Elevators
5. Foot rudder bar (shown separate for clearness)
6. Rudder
7. Fairings

Diagrammatic explanation of the vortices formed by an aircraft in flight. They arise from around the wing and form as wing tips and also in the slipstream of the airscrew.

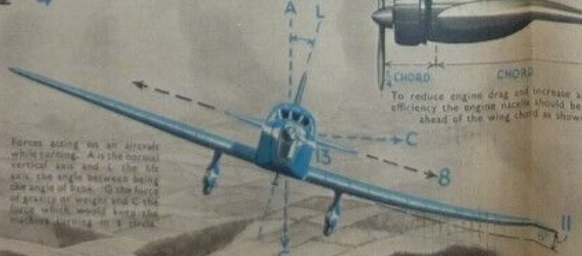
Anti-stalling device common on birds. The small wing and its position on the main wing and, below, close-up view of it open in "stalled" flight. An interesting comparison with Handley Page's invention.



AERODYNAMIC BALANCE

Types of rudders and ailerons showing how the pilot is assisted in moving the controls by the air pressure acting on the balanced portions (shown shaded).

To reduce engine drag and increase airscrew efficiency the engine nacelle should be placed ahead of the wing chord as shown.



Forces acting on an aircraft while turning. A is the normal vertical axis and L the lift axis, the angle between being the angle of bank. G the force of gravity or weight and C the force which would keep the machine turning in a circle.

ASHWELL WOOD

AERODYNAMICS

(above and left)

Four Forces acting on an Aircraft in flight

1. Force of thrust pulling forward
2. Force of lift pulling upward
3. Force of gravity pulling downward
4. Force of drag pulling backward
5. Centre of gravity where all forces meet

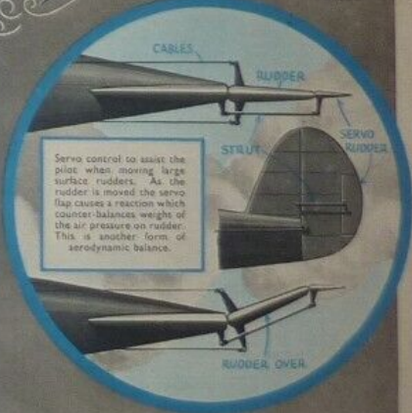
Three Axis about which an Aircraft turns in flight

6. Vertical axis about which it turns directionally
7. Longitudinal axis about which it rolls laterally
8. (Left). Lateral axis about which it pitches longitudinally

Angles of Aerofoils

9. The angle of incidence
10. The angle of attack formed by the wing and direction of wind
11. (Left). The angle of dihedral
12. Centre of pressure where lift forces are acting
13. (Left). Centre of drag where resistance is centred

Owing to the excessive speed at which modern aircraft land, flaps are used to pull them up quickly. They are also used for increasing the lift when taking off. Eddies of air are formed behind the wing, by increasing the incidence.



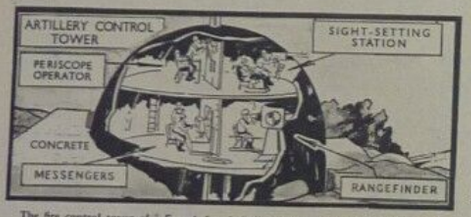
Servo control to assist the pilot when moving large surface rudders. As the rudder is moved the servo flap causes a reaction which counter-balances weight of the air pressure on rudder. This is another form of aerodynamic balance.

The remarkable similarity between the wing of a gull, which is very efficient, and the wing of a modern aircraft. Another lesson from Nature.

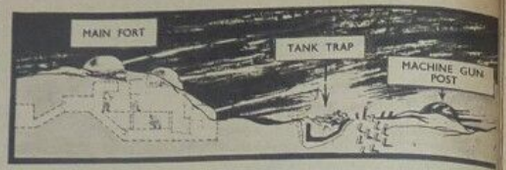
(Left) "Airscrew torque" caused by the drag of the blades tends to tilt the aircraft in the opposite direction to the revolving airscrew. This is counteracted by giving one wing more incidence.

(Right) The blades of an airscrew are really small aerofoils and behave in exactly the same way. The "lift" is now the thrust and the "incidence" is now called the pitch. You can see this if you look at the drawing sideways.

The illustration above gives an idea of an enemy attack with the tank caught in a so-called "asparagus bed." Steel rails driven into the ground are designed to tear off the tank's caterpillar tracks.



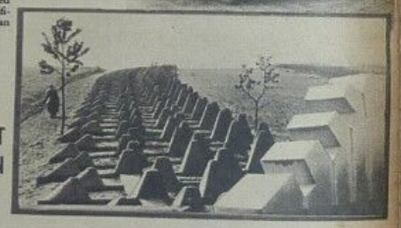
The fire control tower of a French fort is built and partly concealed in the side of a hill.



In addition to the underground fortifications of the Maginot Line there are various other devices designed to prevent the advance of an enemy across France's eastern frontier.

DEFENCE

(*Right*) Concrete anti-tank barricades erected as part of the fortifications of the German Siegfried Line.



BY HERBERT CLARKSON

AMONG many of the world's keenest military observers the belief is rapidly gaining ground that the lumbering, caterpillar-tractored, steel-sheathed, mobile forts—tanks—are already obsolescent and should be scrapped.

Some of America's ranking military experts have expressed the opinion quite definitely that these weapons are of extremely limited usefulness. And not a few of the General Staff have hazarded the prediction that in an engagement on steep and broken terrain they would prove a frightful encumbrance. Further, a tank might be converted into so much immobile junk through heavy rains over soft ground, such as the ploughed land of a farming area.

As a result of lessons learned from the recently-ended conflict in Spain, the United States Army has developed a powerful new anti-tank gun firing a projectile which will penetrate one-and-one-half-inch of armour plate a half mile away.

In battles between the tank and anti-tank defence, the latter in practically every instance proved itself immensurably superior. And this at a time when anti-tank defence was in only the initial stages of development. In this connexion, there can be no questioning that the possibilities for future development are definitely greater for the defence than for the tank itself.

The most sweeping indictment of tanks, that is, as to their value in modern warfare, based on observations in Spain, appeared in a recent number of *Army Ordnance*, the official publication of the Army Ordnance Association of the United States.

Writing in the same official journal Lieutenant-Colonel G. M. Barnes, ordnance engineer, describes the new tank gun which is now to be used by the American Army. He said it was developed as a defence against mass attacks of tanks, such as were employed in the Spanish civil war.

Weighing but 900 pounds, the weapon can be readily moved in manoeuvres and battle. It is of .37 millimetre calibre. Army ordnance plants are now busy turning out the new guns. Funds for their manufacture were included in the administration's arms and expansion programme.

Lieutenant-Colonel Barnes said the anti-tank gun was developed as a counter weapon, in much the same manner as the anti-aircraft gun to bring-down warplanes or keep them out of range.

The story of the tank and its boped-for possibilities are linked with that most vexatious of all military questions—stalemate in the field. It is interesting, too, in showing how keen militarists are often poor prophets. When it comes down to estimating the real worth of a weapon, time and actual conflict are the only real tests.

Professional soldiers have always been reluctant to accept as final the apparent inabilities of armies to bring about a decision in the field. While trying to adapt the equipment and training of the infantry as far as possible to new conditions they turned for the decision to the instrument that in the World War contributed most to the final success, the tank.

Thus, the great military powers were to plunge heavily on the tank as the weapon of all weapons. As a result the tank was to be entrusted with the task of the decisive break-through, either (as in the World War) in strict connexion with the advancing infantry, or else (because the increasing speed of tanks makes this more and more difficult) acting independently, and leaving the infantry to follow in its wake.

With the increase in the speed of the tank, together with the extraordinary technical mobility imparted to modern armies by the large-scale adoption of mechanized and motorized units, the militarists felt certain they would regain strategical mobility, and thus prevent tactical deadlock—stalemate—altogether.

Strong forces of light and highly mobile tanks, followed by motorized divisions, would break through gaps in the enemy's advance or, better still, catch him in his comparatively unguarded flank, before he could settle down upon a stable and continuous front—that is in well-protected trenches. Such was the picture visualized by the post-war tacticians and strategists.

Now the outstanding lesson of the Spanish civil war is that the tanks failed dismally and absolutely to live up to the hopes of the military experts!

But, withal, the rumble of the tanks still echoes throughout the world. The mechanized monsters of Hirohito's invaders still scuttle across the scorched terrain of China, with frequent reports of many floundering and finally disappearing in flooded lands. To the roar of mimic warfare the armoured divisions of Germany, the rattling "panzers," the Hitler-favoured type of tank go lumbering through the Nazi-decorated avenues of Berlin and other large cities of the Reich.

In Italy, the "celere" divisions—tanks, motor cycles, motorized artillery—practise the art of swift, implacable assault.

The French, a logical people, while not abandoning their tanks, are quietly buying mules. Not has the horse been wholly replaced by the tank in France. At Saur, the great French cavalry training school, the traditions of sweat and leather remain.

There is no separate tank organization in the United States Army. Some officers contend that such a corps should be created. The development of mechanization has been entrusted to two separate arms—the cavalry and the infantry. Both have tanks. The double-turreted light tank, which the dough-boys have christened "the Mae West," and the 15-to-18-ton tanks move with the infantry.

The cavalry, which calls its tanks combat cars, also has armoured cars, scout cars, half-tracks—vehicles with regular steering wheels but with tracks instead of wheels—motor cycles, and a motley collection of other queer-looking vehicles. The only completely mechanized unit of America's military organization rolls under the standards of the cavalry.

During the World War the most effective answer to the tank was the tank itself. But today it is the new tank guns. It almost goes without saying that some member of the American House of Representatives will soon question the military experts of Washington as to the wisdom of continuing the building of tanks. He will want to know just what good is a tank, if there is a weapon which will immediately put it out of commission with one or two well-aimed shots.

All around, the tank is the most vulnerable of weapons. It has many tender spots—its engines, its petrol tanks, its ammunition magazines, its human personnel, its very tracks. Rendering it immobile is not at all difficult, and without mobility vanishes its only excuse for existence.

The French have also evoked a tank destroyer—it is a "soup-plate bomb." Safe and easy to handle, a soldier can carry several under his arm. Scattered over the terrain where tanks are expected to advance, covered with dirt, or tossed under the oncoming steel monsters, they'll reduce, so it is claimed, the machines to a heap of molten scrap.

The light tanks in the Spanish civil war enjoyed no protection against such simple weapons as a steep-sided ditch, a hand grenade, or a squirt of flaming petrol.

Every country in Europe, regardless of frontier fortifications, such as the Maginot and Siegfried lines, is encircled by special tank defences. Even Holland and Belgium have erected barriers against the tanks.

Along the frontiers are now to be seen rows upon rows of "poles," lending to the surrounding dun of the countryside a vineyardy aspect. But those upright things, immovable, mysterious, and indistinguishable in the haze, while resembling the poles in vineyards are nothing of the sort. They are sentinels of steel—railway "irons" or rails, anchored in cement bases, buried in the earth.

With most of them showing only three or four feet above the surface, and others a bit higher, they stand forth as mute, but deadly barriers to all types of mechanized war equipment. Planted in parallel rows, eight or ten of them, across the hollows between ridges or hillocks, they constitute the most murderous defence ever devised against tanks.

All around, the tank is the most vulnerable of weapons. It has many tender spots—its engines, its petrol tanks, its ammunition magazines, its human personnel, its very tracks. Rendering it immobile is not at all difficult, and without mobility vanishes its only excuse for existence.

All highways leading into the towns and cities of Belgium and Holland are decorated with these sentinels of steel. In addition they are also planted on the frontiers of the two small powers.

Messy tangles of shrubbery, running parallel to the outer row of steel uprights, are also flourishing in riotous profusion along the international boundary lines of Europe. Seemingly, wild underbrush. Actually, barbed wire woven together in deceptively cruel masses.

In the bright green of summer time, the rolling landscape in front of the almost unbroken line of French, German and Belgian fortifications, strikes the unwary eye as serene and peaceful—and safe.

Indeed, a terrain where every blade of grass is freighted with potential death!

A ribbony stretch of land, dotted with huge, man-dug pits—pits in which the largest tanks might drop out of sight, and then be blown into fragments by ground mines.

All serene and peaceful—but not safe. The French call their steel-rail traps "asparagus beds." In testing the barriers with their own tanks, they found that the uprights caused the mobile forts to see-saw, and tear off their caterpillar tractors. Enemy tanks in such a predicament along the Maginot Line would be subjected also to anti-tank gun fire, at ground level. The line of fire could be directed into the tank's vital parts.

In connexion with the use of tanks in war, a paradoxical situation has arisen in Germany's military establishment. The technicians of the Nazi war machine have perfected a shell with a specially prepared thermite filling fired by normal anti-tank guns. These shells, exploding inside the tank, develop 4,000 degrees Centigrade of heat, as a result of which steel and iron are reduced to a molten mass.

But, just the same, Hitler is still building tanks—tanks larger than the lumbering seventy-tonners which France started turning out several years ago. When tested these mastodons of steel were found by France to be unmanoeuvrable.

If tanks are to play an important part in the next war, which now seems most unlikely, many a supply officer will be driven insane trying to provide petrol and ammunition for an isolated brigade of tanks deep in enemy territory.

The dominance of the supply service has brought about a lack of mobility in war greater than that of the pre-Napoleonic era. One is intrigued by the fact that, after the greatest battle of the World War, the great armies of the Allies were unable to march on the capital of their defeated foe. Why?

Because the masses deemed to be necessary in Berlin could not be transported over the existing routes. Railway systems had been destroyed or become disorganized, and no other medium for transporting the masses and their supplies could be entertained.

As to what might happen to a vast "cavalcade" of tanks, suffering from a fuel shortage or a number of breakdowns in the advance line, can only be conjectured. The fear of such a happening is why certain American military experts regard the tank as an encumbrance.

Napoleon's dictum that "an army marches upon its stomach" is of even more vital significance today, when the mechanization of modern warfare has revolutionized the methods and principles of supply.

That "stomach," in the military sense, is fast becoming a machine involving all kinds of gadgets as well as calories.

Time and again in the history of war a new weapon, such as the tank, has been evolved, with the promise—as well as the hope—that it would prove superior to all other forms of attack or offence.

Time and again pre-war optimism as to the invulnerability of a new weapon has been profoundly modified by the realities of conflict. Eventually there comes an answer to every new weapon—a superior defence.

The British Army has its tanks, some of them small others large, but all fast and wonderfully manoeuvrable and skilfully handled by members of the Tank Corps. But we also have our anti-tank guns, some of the most efficient in the world, guns specially developed to destroy the machines in which so much faith was placed in their early days. Our sea borders make it unnecessary to develop anti-tank precautions along our frontiers but the British Army is well equipped to deal with the tank should any of these machines be met with in the field.

In the illustration above can be seen listening posts, land mines, barbed wire entanglements and fields of iron posts. There are also deeply laid tank traps.

Against TANKS

NEW DEFENCES MAY MAKE TANKS USELESS IN MODERN WARFARE AND THEY MAY BE SCRAPPED BECAUSE OF THE WEAPONS DEVISED TO TRAP AND DESTROY THEM—is the opinion of some experts

Tank traps are disguised to make it difficult for the enemy to locate them. Boughs of trees cover the trap, and once a tank has fallen in it is impossible for it to get out under its own power.

Anti-tank machine gun outposts are built in forward positions to prevent any surprise attack.

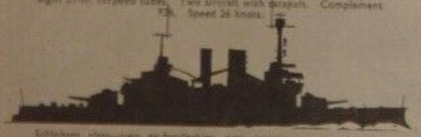
HITLER'S PIRATE NAVY

BATTLESHIPS

Bismarck class—four ships 35,000 tons. Length 729½ ft., beam 118 ft. Guns: Eight 13-in., twelve 5.9-in. Four aircraft and two catapults. Designed for a speed of 30 knots.

Scharnhorst class—two ships, 26,000 tons. Length 741½ ft., beam 98½ ft. Guns: Nine 11-in., twelve 5.9-in., fourteen 4.1-in., sixteen 37-mm. A.A. Four aircraft and two catapults carried. Complement 1,461.

Pocket Battleships. Owing to *Graf Spee*—two ships. Length 609½ ft., beam 67½ ft (Deutschland); 69½ ft. (Scheer). Guns: Six 11-in., eight 5.9-in., six 4.1-in. A.A., eight three-pounder A.A., ten machine guns, eight 21-in. torpedo tubes. Two aircraft with catapults. Complement 926. Speed 26 knots.



Schleswig class—two, ex-battleships, now training vessels. Length 419 ft., beam 73 ft. Armament: Four 11-in., ten 5.9-in., four 3.5-in. A.A., four machine guns. Torpedo tubes removed. Complement 718. Speed 16 knots.

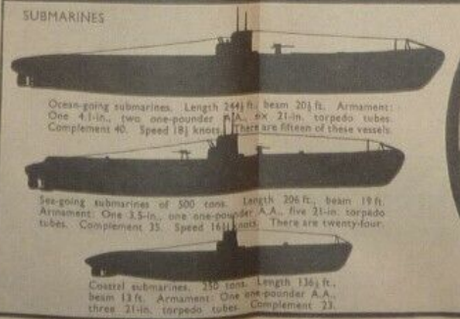
AIRCRAFT CARRIERS

Graf Zeppelin class—two ships, 19,250 tons. Length 820½ ft., beam 88½ ft. Armament: Sixteen 5.9-in., ten 4.1-in A.A., twenty-two 37-mm. A.A. Carries forty aircraft with top speed of 32 knots.

FRIESENLAND—New type of vessel about which little is known. Appears to be latest type of aeroplane carrier and is equipped with special landing and stowing gear.

RANKS

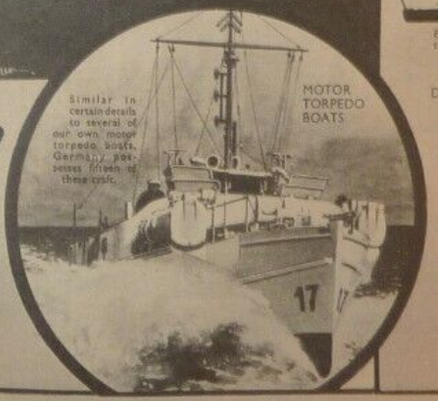
SUBMARINES

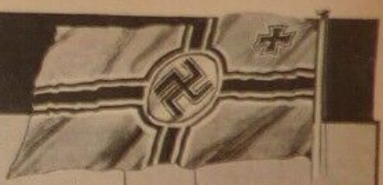


Ocean-going submarines. Length 244½ ft., beam 20½ ft. Armament: One 4.1-in., two one-pounder A.A., six 21-in. torpedo tubes. Complement 40. Speed 18½ knots. There are fifteen of these vessels.

Sea-going submarines of 500 tons. Length 206 ft., beam 19 ft. Armament: One 3.5-in., one one-pounder A.A., five 21-in. torpedo tubes. Complement 35. Speed 16½ knots. There are twenty-four.

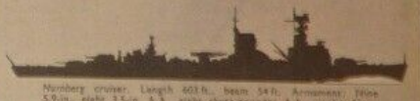
Coastal submarines, 250 tons. Length 136½ ft., beam 13 ft. Armament: One one-pounder A.A., three 21-in. torpedo tubes. Complement 23.



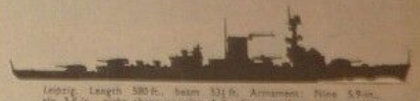


CRUISERS

Hipper class—five ships. Length 639½ ft., beam 69½ ft. Armament: Eight 8-in., twelve 4.1-in. A.A., twelve 37-mm. A.A., twelve 21-in. torpedo tubes. Three aircraft, one catapult. Complement unknown. Speed 32 knots.



Nurnberg cruiser. Length 603 ft., beam 54 ft. Armament: Nine 5.9-in., eight 3.5-in. A.A., eight three-pounder A.A., twelve 21-in. torpedo tubes. Two aircraft with catapult. Complement 656. Speed 32 knots.



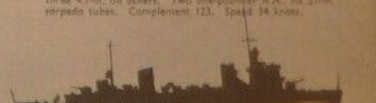
Leipzig. Length 580 ft., beam 53½ ft. Armament: Nine 5.9-in., six 3.5-in., eight three-pounder A.A., four machine guns, twelve 21-in. torpedo tubes. Two aircraft with catapults. Complement 615. Speed 32 knots.

Konigsberg class—three ships 6,000 tons. Length 570 ft., beam 49 ft. Armament: Nine 5.9-in., six 3.5-in., eight three-pounder A.A., four machine guns, twelve 21-in. torpedo tubes. Two aircraft with catapults. Complement 571. Speed 32 knots.

Emden. Length 508½ ft., beam 47 ft. Armament: Eight 5.9-in., three 3.5-in. A.A., four machine guns, four 19.7-in. torpedo tubes. Complement 534. Speed 29 knots.

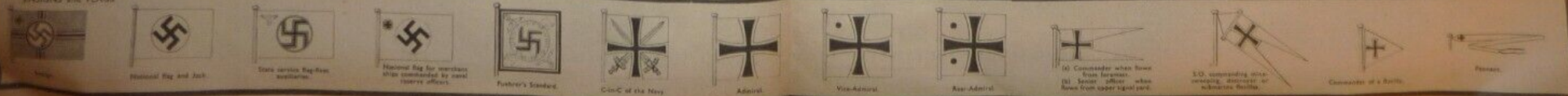
DESTROYERS

Wolf class torpedo boats—six ships. Length 304-ft., beam 28 ft. Armament: Three 5-in. guns on two of ships, three 4.1-in. on others. Two one-pounder A.A., six 21-in. torpedo tubes. Complement 123. Speed 34 knots.



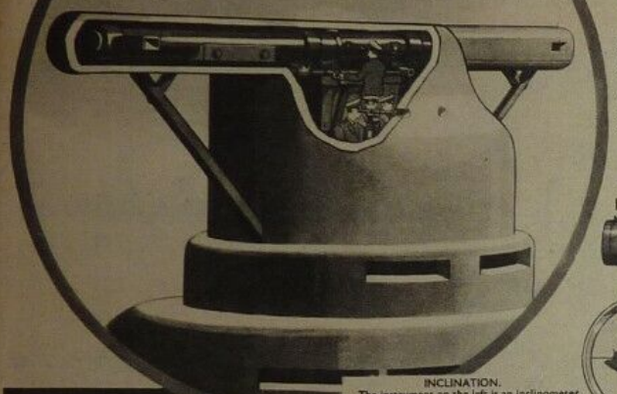
The F and FXI are two new designs for destroyers which are still, according to reports, only projected, and as yet no details of size, performance or armament are available.

ENSIGNS and FLAGS



MECHANICAL BRAIN TRACKS AIR RAIDERS

A 20-ft. range-finder in the fire control top of a British battleship. Here the instrument juts out on either side in its casing of armour plate. The information obtained is transmitted to the gun turrets, which also check up on their own range-finders and the mean range is arrived at. The training telescopes in the control top are below the range-finder in the revolving hood.



RANGE-FINDING today is of paramount importance in supplying the correct ranges for firing guns of all types, and on these pages we endeavour to explain the mysteries of range-taking in a simple manner.

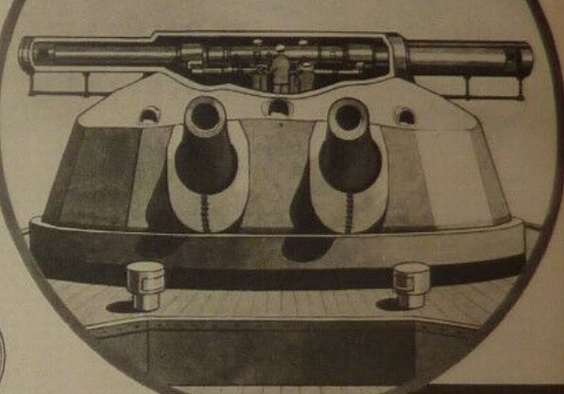
The range-finder, in its simplest form, is the view obtained by the human eyes, which gives the sense of distance. If our eyes were placed farther apart we should be able to estimate distance more accurately, and one form of range-finder consists of an instrument in which this distance is extended to form a long base line.

Measuring the range is based on solving a triangle, the apex being the target and the base representing the length of the range-finder. Now the accuracy of a range-finder depends on two factors, namely the base length and the magnification. The greater this base length the greater will be the parallax.

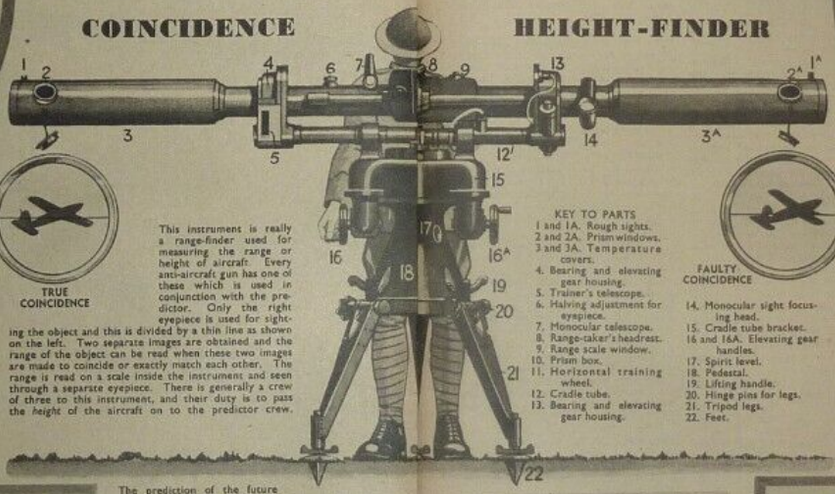
There are two principal types of range-finders known respectively as the coincidence and stereoscopic. In the former only one eyepiece is used for sighting the target whilst the other eyepiece is used for reading the scale.

In the stereoscopic range-finder both eyes are used simultaneously in sighting the object, the focal plane of the two eyepieces fuse into a single image. But this instrument can only be used by persons endowed with stereoscopic vision. This type enables range to be determined with speed and accuracy, but it has the disadvantage that stereoscopic vision fails under stress, and thus the instrument tends to become inaccurate if the operations are extended over a long period. The famous firm of Barr & Stroud have done much to place English range-finders in the forefront which position was previously held by the Germans.

Here is a 30-ft. range-finder mounted on the top of a 15-in. gun turret. This also has an armoured case. The operation of taking range and bearing is done by the "range-finding party," and as the mechanical computations that follow are based on these results, it is necessary that extreme accuracy should be attained.



COINCIDENCE HEIGHT-FINDER



TRUE COINCIDENCE

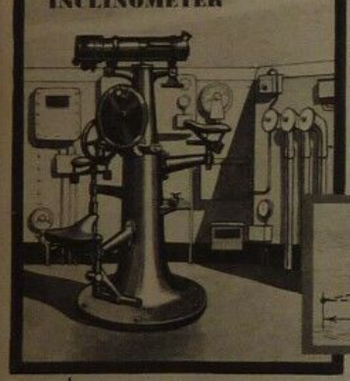
FAULTY COINCIDENCE

This instrument is really a range-finder used for measuring the range or height of aircraft. Every anti-aircraft gun has one of these which is used in conjunction with the predictor. Only the right eyepiece is used for sighting the object and this is divided by a thin line as shown on the left. Two separate images are obtained and the range of the object can be read when these two images are made to coincide or exactly match each other. The range is read on a scale inside the instrument and seen through a separate eyepiece. There is generally a crew of three to this instrument, and their duty is to pass the height of the aircraft on to the predictor crew.

KEY TO PARTS

1 and 1A. Rough sights.
2 and 2A. Prism windows.
3 and 3A. Temperature covers.
4. Bearing and elevating gear housing.
5. Trainer's telescope.
6. Halving adjustment for eyepiece.
7. Monocular telescope.
8. Range-taker's headrest.
9. Range scale window.
10. Prism box.
11. Horizontal training wheel.
12. Cradle tube.
13. Bearing and elevating gear housing.
14. Monocular sight focusing head.
15. Cradle tube bracket.
16 and 16A. Elevating gear handles.
17. Spirit level.
18. Pedestal.
19. Lifting handle.
20. Hinge pins for legs.
21. Tripod legs.
22. Feet.

INCLINOMETER

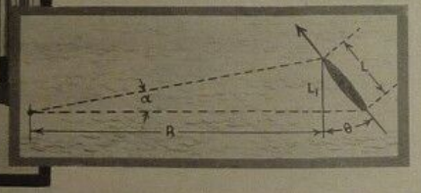


INCLINATION.

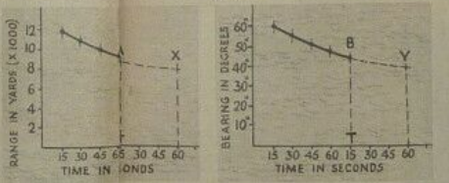
The instrument on the left is an inclinometer mounted in the gun-control platform of a warship. This instrument is rather interesting as it embodies some valuable characteristics. Let us assume that a target ship is travelling on a course (as shown below) at a range R. The view obtained is fore-shortened owing to the angle θ. If L is the length of the ship, the apparent length will be L_1. If α is the angle, subtended by L_1, then we can make this equation.

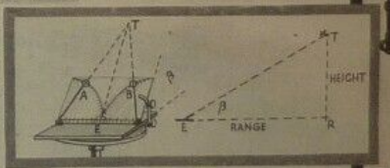
$$R\alpha = L_1$$
$$L_1 = L \cos \theta$$
$$R\alpha = L \cos \theta$$
$$\text{or } \cos \theta = \frac{R\alpha}{L}$$

R is determined by a range-finder, and length of ship L from reference book. The angle α is read from the inclinometer, then the course of target-ship is immediately known.



The prediction of the future position of a target at sea may be worked out in simple form by the variations of range and bearing with time. The bearing and range being given we can work out two graphs as shown. If the shell takes forty-five seconds to reach the target we shall produce a curve on each graph equivalent to this time, i.e., A to X (*left*) and B to Y (*right*). X is then the correct range and Y the bearing for a shell if it is fired at the time marked T. Actually these operations are performed mechanically.

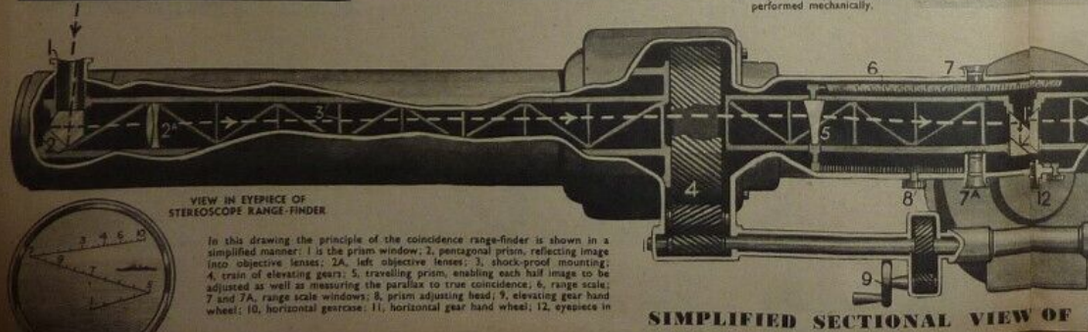




PREDICTION.

This wonderful instrument, shown on right, almost thinks. It gives the course of the aircraft in mathematical calculation automatically to the predictor's crew. The diagram below gives an elementary explanation of part of its work. A horizontal table capable of rotation has a square glass scale hinged to it (E). Two sights, A and B, are also hinged. Both these sights are moved until on the target T, and the angles they make with the base E are equal. This base length is then read and the distance of the target calculated. From these calculations the future position of the target is worked out on a time basis. This information is passed to the gunners who fire their gun on the presumption that the aircraft will "run into" their fire.

PREDICTOR



VIEW IN EYEPIECE OF STEREOSCOPE RANGE-FINDER

VIEW IN EYEPIECE OF COINCIDENCE RANGE-FINDER

In this drawing the principle of the coincidence range-finder is shown in a simplified manner: 1 is the prism window; 2, pentagonal prism, reflecting image into objective lenses; 2A, left objective lenses; 3, shock-proof mounting; 4, train of elevating gears; 5, travelling prism, enabling each half image to be adjusted as well as measuring the parallax to true coincidence; 6, range scale; 7 and 7A, range scale windows; 8, prism adjusting head; 9, elevating gear hand wheel; 10, horizontal gearcase; 11, horizontal gear hand wheel; 12, eyepiece in which the two half images are observed; 12A, central prism combination; 13, training telescope; 14, right elevating gear housing; 15, right objective lenses; 16, pentagonal prism; 17, prism window to the fore. The range is obtained by bringing into exact alignment the two images seen through the eyepiece (12), making the top masts of the ship (shown on right) fit exactly. This is done by moving the prism (5). The range scale (6) is then read through windows (7 or 7A).

SIMPLIFIED SECTIONAL VIEW OF TYPICAL RANGE-FINDER

ASHWELL L. WOOD.